DOE/NV/11718–1143

Nevada Test Site

2005 Data Report:
Groundwater Monitoring Program
Area 5 Radioactive Waste Management Site

February 2006

Prepared for:
U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

Prepared by:
Bechtel Nevada
Post Office Box 98521
Las Vegas, NV 89193-8521

Disclaimer

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors.

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161-0002
Telephone: (800) 553-6847
Fax: (703) 605-6900
E-mail: orders@ntis.gov
Online ordering: http://www.ntis.gov/ordering.htm

Available electronically at http://www.osti.gov/bridge

Available for a processing fee to the U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Telephone: (865) 576-8401
Fax: (865) 576-5728
E-mail: reports@adonis.osti.gov

DOE/NV/11718--1143

NEVADA TEST SITE

2005 DATA REPORT: GROUNDWATER MONITORING PROGRAM AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

February 2006

Worked Performed Under
Contract No. DE-AC08-96NV11718

Prepared for:
U.S. Department of Energy
National Nuclear Security Administration
Nevada Site Office

Prepared by:

P.O. Box 98521
Las Vegas, NV 89193-8521

This Page Intentionally Left Blank

TABLE OF CONTENTS

Page

LIST OF FIGURES

Page

LIST OF TABLES

Page

LIST OF ACRONYMS

AMSL	above mean sea level
BN	Bechtel Nevada
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
E	Easting
GW	groundwater
IL	investigation level
LCA	lower carbonate aquifer
MDC	minimum detectable concentration
MDL	method detection limit
N	Northing
NDEP	Nevada Division of Environmental Protection
NTS	Nevada Test Site
RCRA	Resource Conservation and Recovery Act
REECo	Reynolds Electrical & Engineering Company, Inc.
RWMS	Radioactive Waste Management Site
SC	specific conductance
TOC	total organic carbon
TOX	total organic halides
UGTA	Underground Test Area

MEASUREMENTS

C	Celsius
cm	centimeter
ft	feet
in	inch
L	liter
m	meter
mg	milligram
mmhos	milli-mhos
pCi	picoCurie
µg	microgram
yr	year

EXECUTIVE SUMMARY

This report is a compilation of the calendar year 2005 groundwater sampling results from the Area 5 Radioactive Waste Management Site (RWMS). Pilot wells UE5PW-1, UE5PW-2, and UE5PW-3 were sampled in May and October 2005 for the following indicators of contamination: pH, specific conductance (SC), total organic carbon (TOC), total organic halides (TOX), and tritium. Indicators of general water chemistry (cations and anions) were also monitored. Results from all samples collected in 2005 were within the limits established by agreement with the Nevada Division of Environmental Protection (NDEP) for each analyte. These data indicate that there has been no measurable impact to the uppermost aquifer from the Area 5 RWMS.

There were no significant changes in measured groundwater parameters compared to previous years. Previously, bicarbonate ion (HCO_3) concentrations were reported as the bicarbonate alkalinity as $CaCO_3$ in parts per million. In this report bicarbonate ion concentrations are reported as bicarbonate concentrations calculated from the bicarbonate alkalinity. Also silicate (SiO_2) is reported as the SiO_2 concentration rather than the silicon (Si) concentration.

Other information in the report includes an updated Cumulative Chronology for the Area 5 RWMS Groundwater Monitoring Program and a brief description of the site hydrogeology.

Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
03/20/1990	U.S. Department of Energy (DOE) letter requesting installation of monitoring wells near the Area 5 RWMS.				
03/13/1992	Drilling begins				
06/16/1992	Drilling ends	06/18/1992	Drilling begins		
09/11/1992	Well Developed	09/04/1992	Drilling ends		
09/17/1992	GW Sampling			09/16/1992	Drilling begins
				11/09/1992	Drilling ends
		03/24/1993	GW Sampling		
03/31/1993	GW Sampling	03/30/1993	Well Developed	04/04/1993	Well Developed
				04/14/1993	GW Sampling
07/06/1993	GW Sampling	06/22/1993	GW Sampling	06/02/1993	GW Sampling
09/01/1993	GW Sampling			10/12/1993	GW Sampling
12/07/1993	GW Sampling	11/15/1993	GW Sampling	12/20/1993	GW Sampling
12/17/1993	DOE letter to NDEP requesting to establish Pilot Wells located near the Area 5 as RCRA groundwater monitoring wells.				
		01/19/1994	GW Sampling		
02/24/1994	NDEP letter stating that the Pilot Wells appear to meet the applicable design, construction, and development criteria for RCRA groundwater monitoring wells.				
06/15/1994	GW Sampling	06/07/1994	GW Sampling	05/24/1994	GW Sampling
08/01/1994	GW Sampling			08/08/1994	GW Sampling
		11/29/1994	GW Sampling		
09/30/1994	DOE submits 1993 groundwater-monitoring results from quarterly sampling effort.				
01/18/1995	GW resampling for 08/01/1994 TOC hit.				
02/23/1995	DOE transmits to NDEP Groundwater Monitoring Program Outline.				
03/01/1995	1994 Groundwater Monitoring Report submitted to NDEP.				
04/04/1995	GW Sampling				
11/09/1995	GW Sampling	11/20/1995	GW Sampling	11/09/1995	GW Sampling
11/09/1995	UE5PW-1 pump snagged in hole, resulting in a bent shaft on the reel.				
01/22/1996	Bennett pump seals replaced at all three wells.				
03/01/1996	DOE submits to NDEP the 1995 GW Monitoring Report.				

Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
01/16/1996	GW Sampling				
04/16/1996	GW Sampling				
		04/30/1996	GW Sampling		
10/01/1996	GW Sampling				
10/25/1996	NDEP requests clarifications/changes in the GW Monitoring Report.				
11/19/1996	GW Sampling				
03/01/1997	DOE submits 1996 GW Monitoring Report and revised GW Monitoring Program Outline.				
04/16/1997	GW Sampling				
08/12/1997	NDEP comments on 1996 GW Monitoring Report/Proposed Outline.				
10/22/1997	Pump and water-level meter lodge in UE5PW-1 well during simultaneous operation, retrieved 10/23/1997.				
10/22/1997	Larger diameter air lines installed at all three wells.				
11/05/1997	GW Sampling				
03/01/1998	DOE submits to NDEP the 1997 GW Monitoring Report and new outline.				
03/31/1998	NDEP letter stating that they concur on the indicator parameters and ILs submitted in the groundwater-monitoring outline.				
05/13/1998	GW Sampling				
06/22/1998	TOX detected in the 05/13/1998 samples and blanks from all three wells.				
07/10/1998	DOE and NDEP agree to resample UE5PW-1 to confirm no TOX.				
07/29/1998	GW resampling at UE5PW-1 for 05/13/1998 TOX hits.				
09/10/1998	Results from 07/29/1998 resampling are non-detect for TOX. TOX results from the 05/13/1998 sampling event are determined to be false positives.				
09/10/1998	Bennett pumps from three wells and spare pumps are sent to manufacturer for refurbishing.				
09/12/1998	Reels from three wells are returned to manufacturer for new tubing bundles.				
10/28/1998	GW Sampling				
09/12/1998	UE5PW-1 reel returned to manufacturer for repair of exhaust tube. Spare pump returned to manufacturer for the repair of a leaky seal.				
03/01/1999	DOE submits to NDEP 1998 Groundwater Monitoring Report.				
03/31/1999	NDEP requests statistical analysis of data and states that values determined to be false positives through resampling do not need to be presented graphically.				
05/19/1999	GW Sampling				
10/27/1999	GW Sampling				
12/13/1999	Resample UE5PW-2 after TOC hit from 10/27/1999.				
12/27/1999	Results from the resampling of UE5PW-2 are non-detect for TOC. TOC result from 10/27/1999 is determined to be a false positive.				
02/25/2000	DOE submits to NDEP 1999 Groundwater Monitoring Report				

Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
04/17/2000	NDEP states that future reports do not need to include statistical analyses.				
04/26/2000	GW Sampling				
06/28/2000	DOE contacts state to report TOX/TOC hits from 04/26/2000. DOE and NDEP agree that the wells will be resampled in August, which would also constitute the Fall sampling event.				
08/09/2000	GW Sampling				
09/20/2000	DOE contacts NDEP to report TOX hits from 08/09/2000 sampling.				
11/07/2000	Letter from NDEP stating that DOE does not have a valid data set for TOX and possibly TOC and requests a plan to address contamination concerns prior to next sampling event.				
11/20/2000	Video log well			11/27/2000	Video log well
12/20/2000	DOE transmits to NDEP a proposed plan to address contamination issues.				
01/31/2001	Letter from NDEP generally concurring that the plan submitted to determine the cause of TOX and TOC hits is sound.				
02/21/2001	DOE submits to NDEP 2000 Groundwater Monitoring Report				
03/14/2001	Letter from NDEP stating that the 2000 Groundwater Monitoring report was received in a timely manner and contains all the data required by Title 40 CFR 265.94. Letter also requests information regarding data in Appendix A of the 2000 Groundwater Monitoring Report (Bechtel Nevada [BN], 2001).				
04/19/2001	Letter from DOE responding to NDEP's 3/14/2001 request for information regarding presentation of TOX/TOC data in the 2000 report.				
04/30/2001	Letter from NDEP concurring with the approach to data presentation as outlined by DOE in the 4/19/2001 correspondence.				
05/29/2001	GW Sampling				
10/03/2001	GW Sampling				
03/01/2002	DOE submits to NDEP 2001 Groundwater Monitoring Report				
05/15/2002	GW Sampling				
10/22/2002	GW Sampling				
03/01/2003	DOE submits to NDEP 2002 Groundwater Monitoring Report				
04/15/2003	GW Sampling				
10/22/2003	GW Sampling			10/21/2003	GW Sampling
03/01/2004	DOE submits to NDEP 2003 Groundwater Monitoring Report				
05/04/2004	GW Sampling				
10/19/2004	GW Sampling			10/20/2003	GW Sampling

Cumulative Chronology for Area 5 RWMS Groundwater (GW) Monitoring Program					
Date	**UE5PW-1**	**Date**	**UE5PW-2**	**Date**	**UE5PW-3**
02/25/2005	DOE submits to NDEP 2004 Groundwater Monitoring Report				
04/19/2005	GW Sampling				
10/11/2005	GW Sampling				

This Page Intentionally Left Blank

I. INTRODUCTION

A. Purpose and Scope

This report is a compilation of the calendar year 2005 groundwater sampling results from three monitoring wells located near the Area 5 Radioactive Waste Management Site (RWMS) at the Nevada Test Site (NTS), Nye County, Nevada. The NTS is a 3561 square kilometer (1375 square mile) secure federal installation located approximately 105 kilometers (65 miles) northwest of Las Vegas, NV (Figure 1). Pilot wells UE5PW-1, UE5PW-2, and UE5PW-3 (Figure 2) are used to monitor the groundwater at the Area 5 RWMS. In addition to providing groundwater monitoring results, this report also includes information regarding site hydrogeology, well construction, sample collection, and meteorological data measured at the Area 5 RWMS.

The disposal of low-level radioactive waste and mixed low-level radioactive waste at the Area 5 RWMS are regulated by U.S. Department of Energy (DOE) Order 435.1 and the disposal of mixed low-level radioactive waste is also regulated by the state of Nevada under RCRA regulation Title 40 CFR 265. The format of this report was requested by the Nevada Division of Environmental Protection (NDEP) in a letter dated August 12, 1997. The appearance and arrangement of this document have been modified slightly since that date to provide additional information and to facilitate the readability of the document. The objective of this report is to satisfy any Area 5 RWMS reporting agreements between DOE and NDEP.

B. Site Hydrogeology

The Area 5 RWMS is located in northern Frenchman Flat in the southeast portion of the NTS. Frenchman Flat is a topographically closed basin. Erosion of surrounding low lying mountains has resulted in accumulation of thick, unsaturated, alluvial deposits above volcanic rocks within the basin (Bright et al., 2001). Alluvial and volcanic aquifers are present beneath the Area 5 RWMS and are believed to extend throughout much of the Frenchman Flat basin (International Technology, 1998). In this south-central portion of the NTS, a moderately thick volcanic confining unit (consisting of altered volcanic rocks) separates the shallow alluvial and volcanic aquifers from the underlying regional lower carbonate aquifer (LCA) (Laczniak et al., 1996).

The water from the three monitoring wells UE5PW-1, UE5PW-2, and UE5PW-3 is sodium-bicarbonate type. This water type is common in the upper aquifers in Frenchman Flat. Similar groundwater chemistry and water table elevations in UE5PW-1, UE5PW-2, and UE5PW-3 wells indicate that the alluvial and volcanic aquifers are locally connected near the Area 5 RWMS. UE5PW-1 and UE5PW-2 are completed in the alluvial aquifer and UE5PW-3 is completed in the volcanic aquifer.

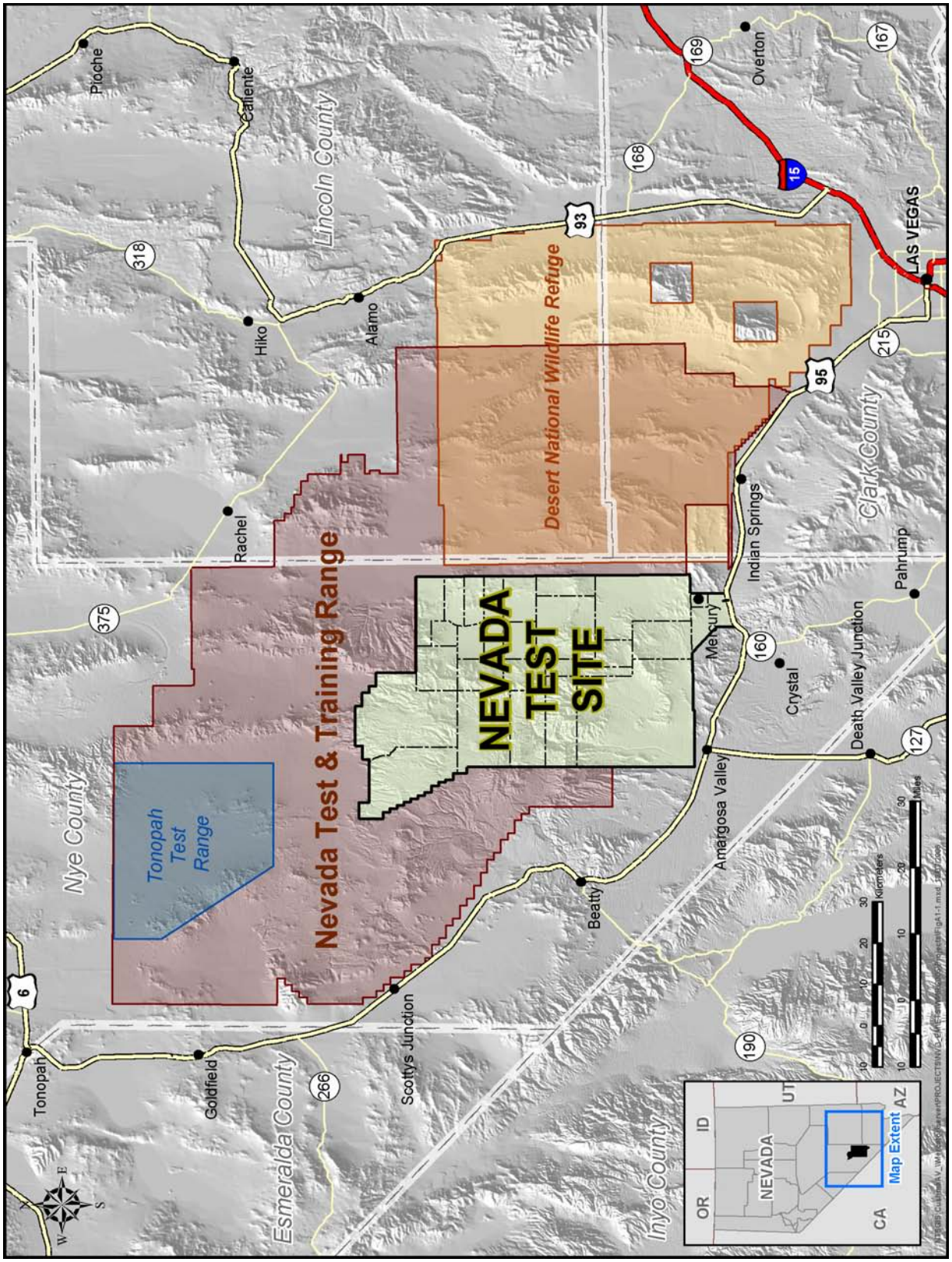


Figure 1 Location of the Nevada Test Site within Nevada

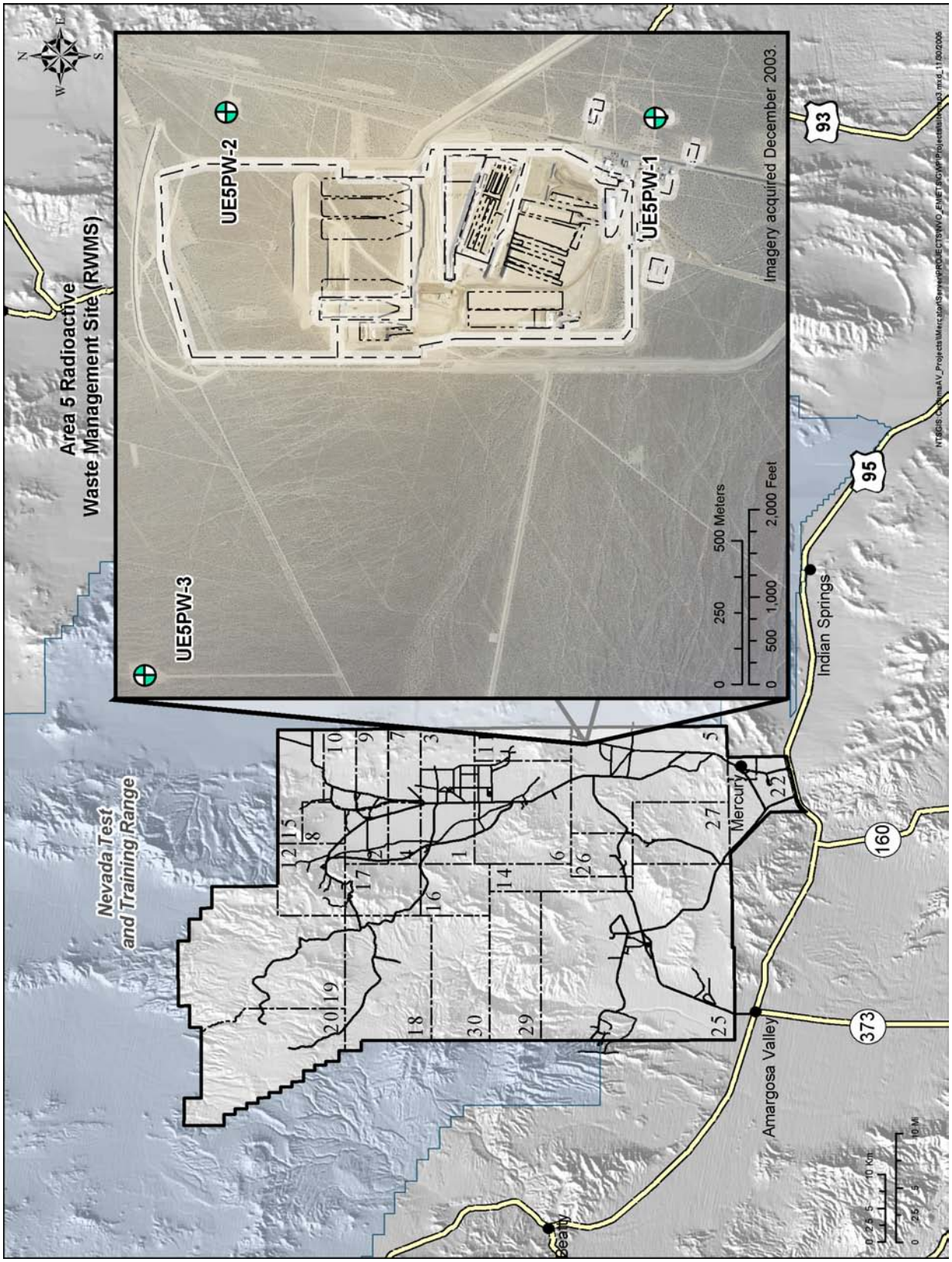


Figure 2 Location of Pilot Wells and Area 5 RWMS within the Nevada Test Site

Some vertical groundwater flow is thought to occur between the uppermost aquifers and the underlying regional LCA. This vertical flow is an area of study by the Underground Test Area Project (UGTA). Based on measured groundwater elevations above mean sea level (AMSL) (Figure 3), the hydraulic gradient in Frenchman Flat is very low. Lateral groundwater movement beneath Frenchman Flat primarily occurs within the deep carbonate aquifer and is generally from the northeast to southwest (Figure 4). Groundwater in the LCA flows to the south and southwest, where it eventually discharges in Amargosa Valley and Ash Meadows in southwest Nevada and Death Valley, California (Figure 4) (Laczniak et al., 1996).

For more detailed descriptions of Area 5 RWMS site characteristics refer to *Revised Area 5 Radioactive Waste Management Site Outline of a Comprehensive Groundwater Monitoring Program* (Bechtel Nevada [BN], 1998).

C. Monitoring Well Descriptions

Pilot wells UE5PW-1, UE5PW-2, and UE5PW-3 were drilled between March and November 1992 and the groundwater has been monitored since 1993. Each well is completed with a centralized 6.35 centimeters (cm) (2.50 inches [in]) diameter stainless steel casing with an 18.3 meter (m) (60 feet [ft]) dual-screen filter pack attached to the bottom of the casing. The borehole annulus below and around the screen is filled with 6/12 coarse mesh sand (Reynolds Electrical & Engineering Company, Inc. [REECo], 1994).

UE5PW-1 is 255.7 m (839 ft) deep from top of casing and is screened from 232.3 m (762 ft) to 250.5 m (822 ft). UE5PW-1 is completed in alluvium. During 2005, the average water table depth below the top of well casing is 235.71 m (773.34 ft).

UE5PW-2 is 280.3 m (919.5 ft) deep from top of casing and is screened from 253.0 m (830 ft) to 271.3 m (890 ft). UE5PW-2 is completed in alluvium. During 2005, the average water table depth below the top of well casing is 256.41 m (841.23 ft).

UE5PW-3 is 291.1 m (955 ft) deep from top of casing and is screened from 267.6 m (878 ft) to 282.9 m (928 ft). UE5PW-3 is completed in volcanic rock. The alluvium-volcanic rock contact is 188 m (617 ft) deep at UE5PW-3 (REECo, 1994). During 2005, the average water table depth below the top of well casing is 271.49 m (890.70 ft).

D. Site Meteorology

Meteorological data are measured at the Area 5 RWMS. These data include temperature, relative humidity, barometric pressure, wind speed and direction, and precipitation. The average annual precipitation measured at the Area 5 RWMS from 1994 through 2005 is 13.2 cm/yr (5.20 in/yr). There was 20.1 cm (7.91 in) of precipitation at the Area 5 RWMS in 2005. Monthly precipitation at the Area 5 RWMS is provided in Figure 5.

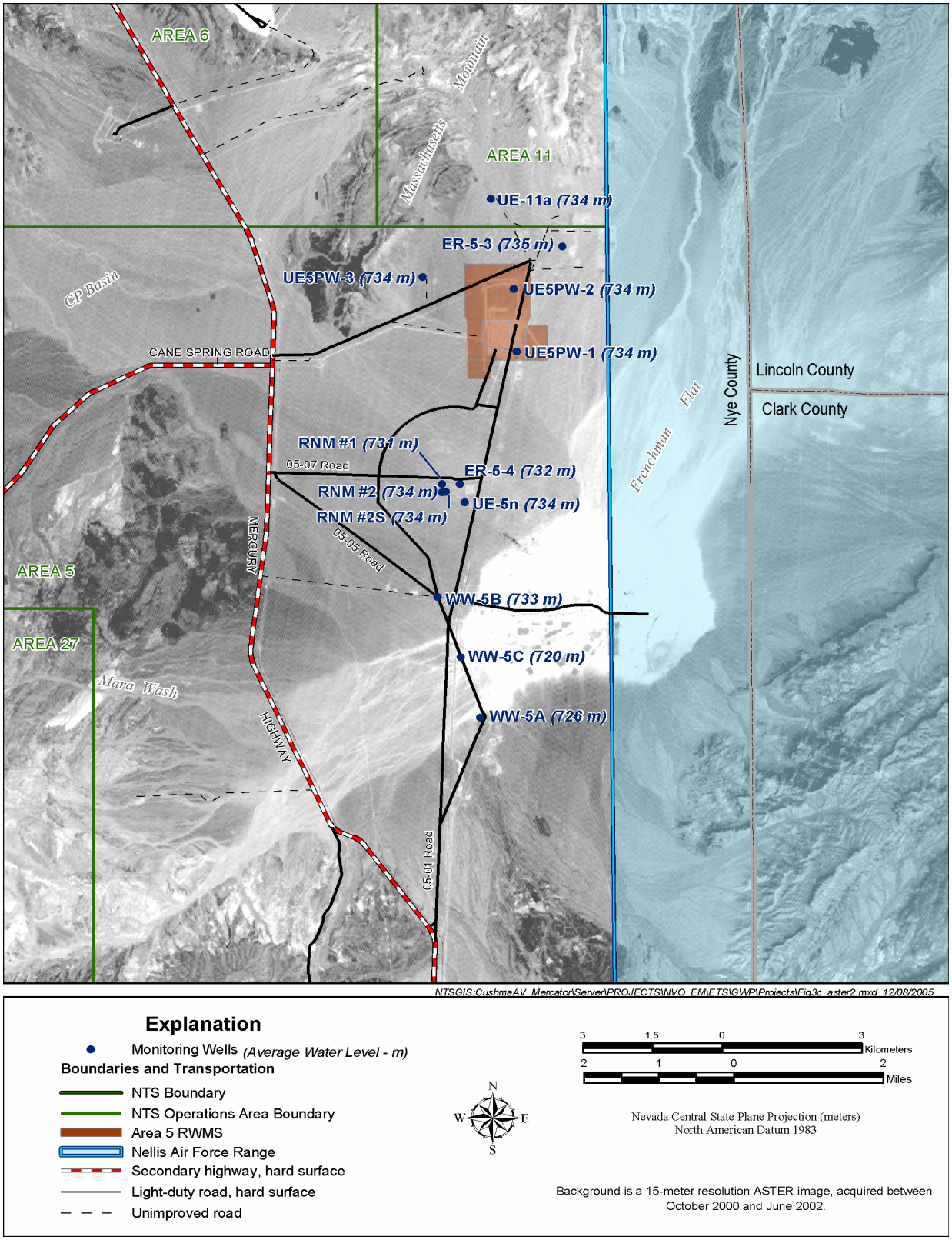


Figure 3 Location and Average Water Level Elevations of Area 5 RWMS Groundwater Monitoring Wells and other Wells in the Vicinity (USGS, 2005)

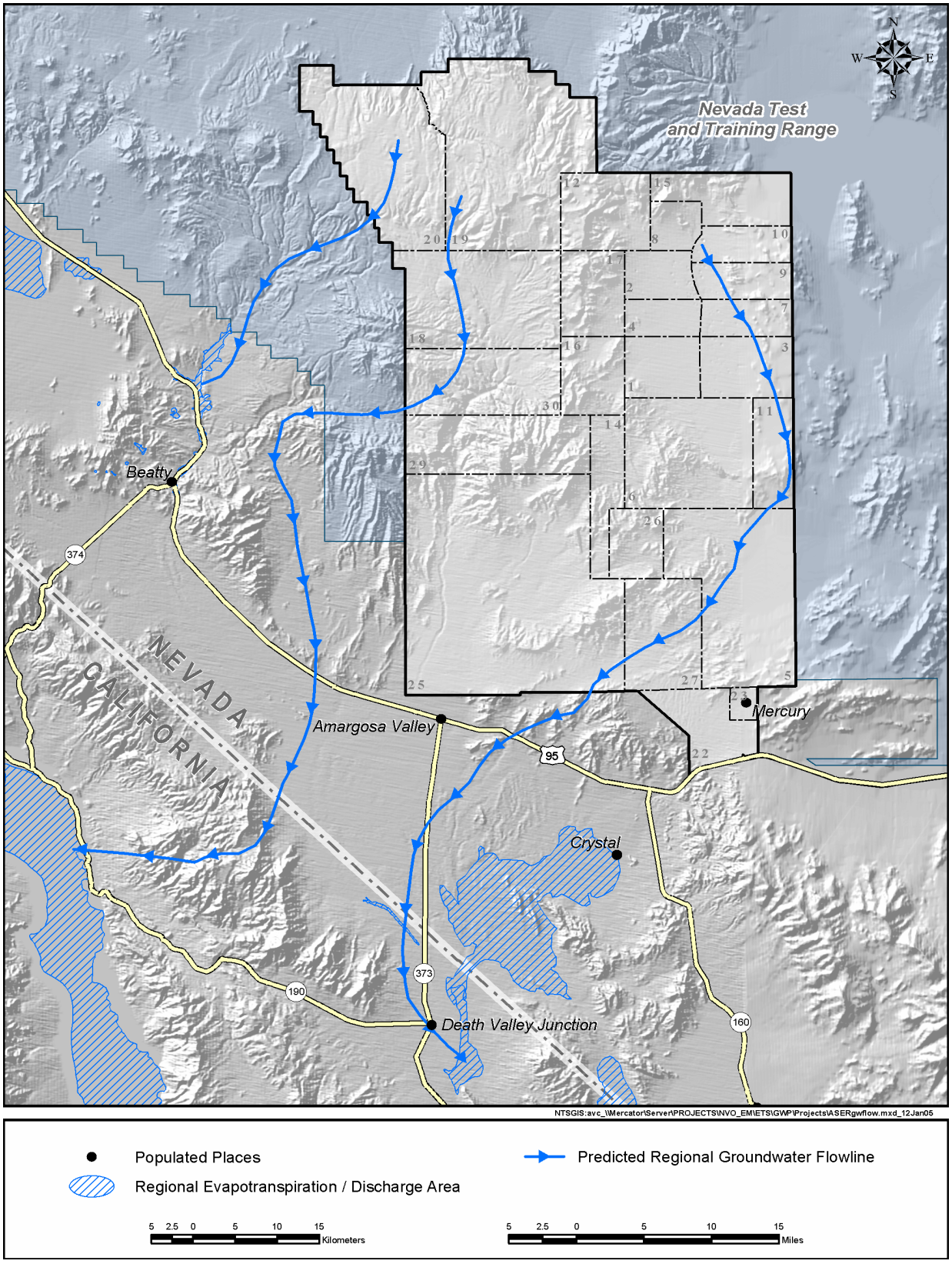


Figure 4 Nevada Test Site Predicted Regional Groundwater Flow Paths (Rehfelt, 2001)

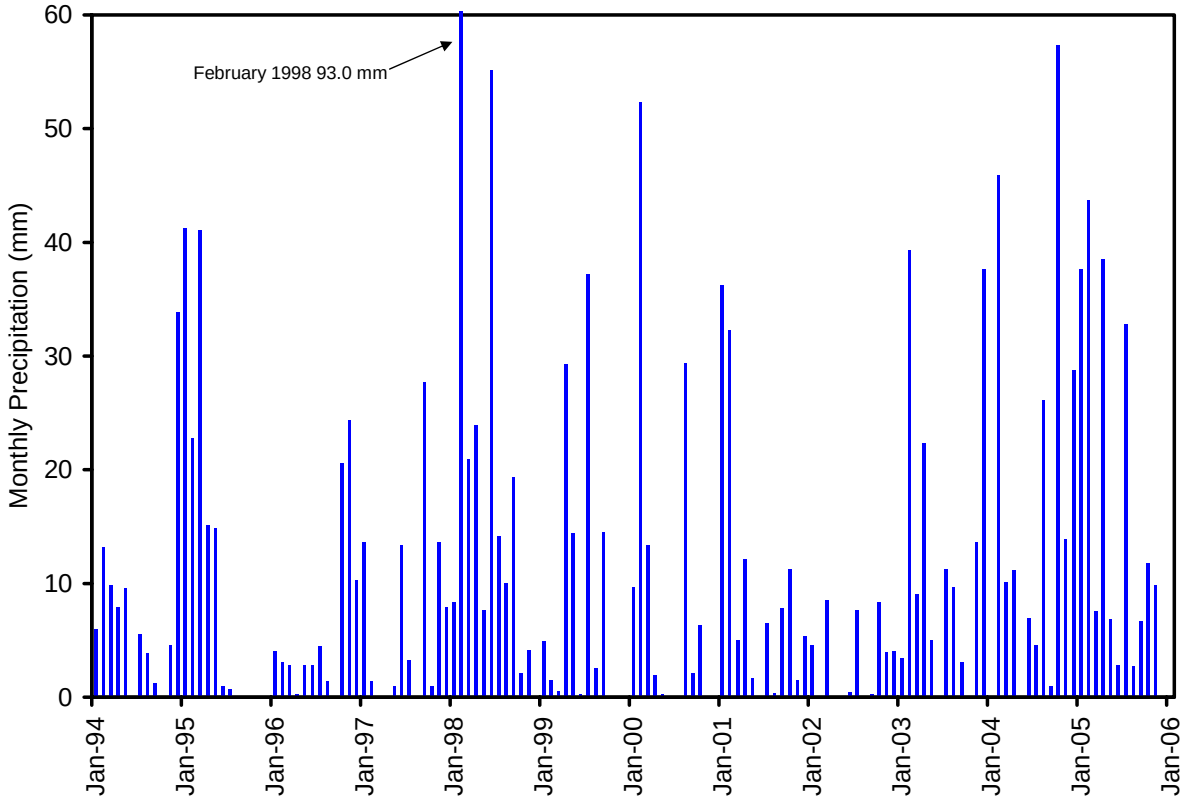


Figure 5 Area 5 RWMS Monthly Precipitation

II. MONITORING METHODS AND RESULTS

The Area 5 RWMS pilot wells have been monitored since 1993. The groundwater monitoring program has transitioned from monitoring all parameters required by Title 40 CFR 265 to a program that monitors parameters applicable to the Area 5 RWMS site. The current monitoring program is modeled after the Title 40 CFR 264 detection-monitoring program. The analytes listed below are sampled semi-annually and are divided into groups representing indicators of contamination and general water chemistry parameters:

Indicators of Contamination

- pH
- specific conductance (SC)
- total organic carbon (TOC)
- total organic halides (TOX)
- tritium

General Water Chemistry Parameters
- Total Ca, Fe, Mg, Mn, K, Na, Si
- Total SO_4, Cl, F
- Alkalinity (HCO_3)

Investigation levels (ILs) for each analyte identified as an indicator of contamination were established by DOE and NDEP in 1998 (Table 1). Further groundwater analyses are required if an analyte's IL is exceeded. The intent of ILs is to replace the need for rigorous statistical analyses to identify contamination. Statistical analyses are not presented in this report, as agreed upon by NDEP in a letter dated April 17, 2000 (Liebendorfer, 2000). The ILs for pH and SC are based on the distributions of data collected from 1993 through 1996. Historic analyses for TOC, TOX, and tritium have typically reported concentration levels less than the method detection limit (MDL) or the minimum detectable concentration (MDC), so the ILs for TOC and TOX are set slightly above their MDLs or MDCs. The tritium IL is set at 2,000 pCi/L, which is 10 percent of the National Primary Drinking Water Standard of 20,000 pCi/L.

Table 1 Investigation Levels for Indicator Parameters

Parameter	Investigation Level (IL)
pH	< 7.6 or > 9.2
SC	0.440 mmhos/cm
TOC	1 mg/L
TOX	50 μg/L
Tritium	2,000 pCi/L

Wells UE5PW-1, UE5PW-2, and UE5PW-3 were sampled on May 19, 2005 and October 11, 2005 using the current BN groundwater sampling procedure (BN, 2005). Tritium samples were enriched by BN prior to shipment to a contract laboratory. Analyses for tritium were conducted by Sanford Cohen & Associates Southeastern Environmental Laboratory and non-radiological analysis were conducted by Lionville Laboratory Incorporated.

For TOC and TOX analysis, three replicate water samples were collected consecutively from each well for each analyte. This provides sufficient sample backups in case any sample result is above the analyte's IL. Well resampling are required if all three replicate water samples are above the analyte's IL. False detections of these analytes above their ILs and subsequent resampling of the wells have occurred in the past.

A. pH

The measured pH at each well remained within the ILs of 7.6 and 9.2 during 2005 (Table 2). The 2005 pH values ranged from 8.27 to 8.47 and represent the stable pH reading obtained from each well just prior to sampling for all other analytes. Measured pH has remained relatively stable throughout the entire monitoring period (Figure 6). No groundwater contamination is indicated by the pH monitoring results.

Table 2 Area 5 RWMS pH Values

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**pH**	**Date**	**pH**	**Date**	**pH**
03/31/1993	8.17	03/24/1993	7.99	04/14/1993	8.24
06/06/1993	8.30	06/22/1993	8.24	06/02/1993	8.67
09/01/1993	8.25	No sample		10/12/1993	8.69
12/07/1993	7.91	11/15/1993	8.39	12/20/1993	8.60
06/15/1994	8.45	06/07/1994	8.81	05/24/1994	8.87
08/01/1994	8.28	No sample		08/08/1994	8.77
No sample		11/29/1994	8.79	No sample	
No sample		No sample		01/18/1995	8.58
04/04/1995	8.25	04/04/1995	8.58	04/05/1995	8.28
11/09/1995	8.35	11/09/1995	8.08	11/09/1995	8.43
01/18/1996	8.41	01/25/1996	8.63	01/18/1996	8.55
04/16/1996	8.22	04/23/1996	8.21	04/23/1996	8.23
No sample		04/30/1996	8.15	04/30/1996	8.15
10/02/1996	8.18	10/02/1996	8.28	10/02/1996	8.18
11/20/1996	8.25	11/20/1996	8.17	11/20/1996	8.13
04/16/1997	8.32	04/16/1997	8.40	04/16/1997	8.25
11/05/1997	8.30	11/05/1997	8.16	11/05/1997	8.22
05/13/1998	8.31	05/13/1998	8.37	05/13/1998	8.34
07/29/1998	8.63	No sample		No sample	
10/28/1998	8.34	10/28/1998	8.32	10/28/1998	8.14
05/19/1999	8.50	05/19/1999	8.49	05/19/1999	8.47
10/27/1999	8.49	10/27/1999	8.52	10/27/1999	8.34
04/26/2000	8.50	04/26/2000	8.39	04/26/2000	8.24
08/09/2000	8.26	08/09/2000	8.14	08/09/2000	8.23
05/29/2001	8.46	05/29/2001	8.25	05/29/2001	8.27
10/03/2001	8.39	10/03/2001	8.22	10/03/2001	8.13
05/15/2002	8.46	05/15/2002	8.30	05/15/2002	8.32
10/22/2002	8.43	10/22/2002	8.23	10/22/2002	8.24
04/15/2003	8.54	04/15/2003	8.38	04/15/2003	8.42
10/22/2003	8.37	10/22/2003	8.24	10/21/2003	8.16
05/04/2004	8.50	05/04/2004	8.25	05/04/2004	8.26
10/19/2004	8.30	10/19/2004	8.32	10/20/2004	8.24
04/19/2005	8.48	04/19/2005	8.30	04/19/2005	8.33
10/11/2005	8.47	10/11/2005	8.27	10/11/2005	8.31

Data source: Data taken from original sample packages or field notebooks and represent the stable pH value measured just prior to sampling.

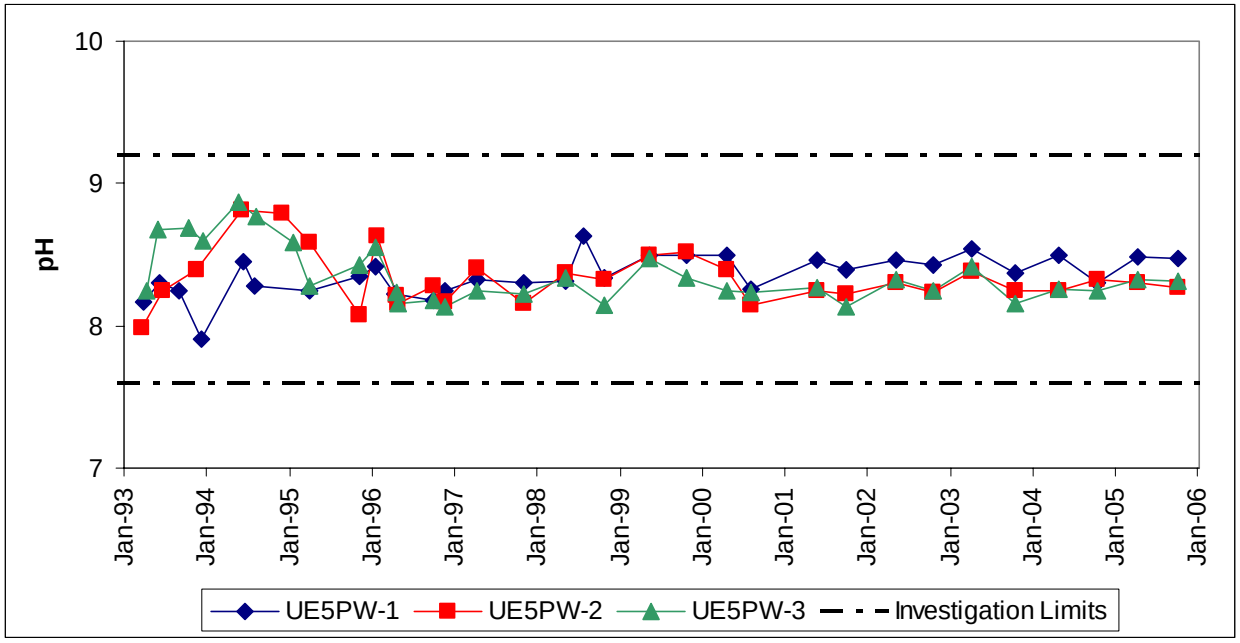


Figure 6 Area 5 RWMS Time Series Plot of pH

B. Specific Conductance

The 2005 measured SC of water samples from each well remained below the IL of 0.440 milli-mhos/centimeter (mmhos/cm) and ranged from 0.352 to 0.377 mmhos/cm (Table 3). SC values from each well have remained relatively stable throughout the entire monitoring period (Figure 7). No groundwater contamination is indicated by the SC monitoring results.

Table 3 Area 5 RWMS Specific Conductance (SC) Values in mmhos/cm

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**SC**	**Date**	**SC**	**Date**	**SC**
03/31/1993	0.401	03/24/1993	0.371	04/14/1993	0.383
06/06/1993	0.391	06/22/1993	0.411	06/02/1993	0.382
09/01/1993	0.391	No Sample		10/12/1993	0.376
12/07/1993	0.383	11/15/1993	0.384	12/20/1993	0.356
06/15/1994	0.383	06/07/1994	0.363	05/24/1994	0.363
08/01/1994	0.380	No Sample		08/08/1994	0.367
No Sample		11/29/1994	0.325	No Sample	
No Sample		No Sample		01/18/1995	0.338
04/04/1995	0.320	04/04/1995	0.336	04/05/1995	0.347
11/09/1995	0.366	11/09/1995	0.348	11/09/1995	0.352
01/18/1996	0.360	01/25/1996	0.343	01/18/1996	0.355
04/16/1996	0.363	04/23/1996	0.355	04/23/1996	0.363

Table 3 (continued)

UE5PW-1		UE5PW-2		UE5PW-3	
Date	**SC**	**Date**	**SC**	**Date**	**SC**
No Sample		04/30/1996	0.356	04/30/1996	0.379
10/02/1996	0.383	10/02/1996	0.363	10/02/1996	0.376
11/20/1996	0.374	11/20/1996	0.365	11/20/1996	0.378
04/16/1997	0.385	04/16/1997	0.363	04/16/1997	0.376
11/05/1997	0.376	11/05/1997	0.358	11/05/1997	0.361
05/13/1998	0.377	05/13/1998	0.356	05/13/1998	0.370
07/29/1998	0.373	No Sample		No Sample	
10/28/1998	0.380	10/28/1998	0.358	10/28/1998	0.370
05/19/1999	0.379	05/19/1999	0.351	05/19/1999	0.369
10/27/1999	0.370	10/27/1999	0.355	10/27/1999	0.370
04/26/2000	0.378	04/26/2000	0.355	04/26/2000	0.369
08/09/2000	0.378	08/09/2000	0.357	08/09/2000	0.370
05/29/2001	0.377	05/29/2001	0.358	05/29/2001	0.371
10/03/2001	0.376	10/03/2001	0.358	10/03/2001	0.371
05/15/2002	0.386	05/15/2002	0.374	05/15/2002	0.384
10/22/2002	0.374	10/22/2002	0.368	10/22/2002	0.368
04/15/2003	0.372	04/15/2003	0.355	04/15/2003	0.369
10/22/2003	0.376	10/22/2003	0.357	10/21/2003	0.373
05/04/2004	0.378	05/04/2004	0.361	05/04/2004	0.353
10/19/2004	0.372	10/19/2004	0.352	10/20/2004	0.365
04/19/2005	0.377	04/19/2005	0.359	04/19/2005	0.369
10/11/2005	0.368	10/11/2005	0.352	10/11/2005	0.364

Data source: Data taken from original sample packages or field notebooks and represent the stable SC value measured just prior to sampling.

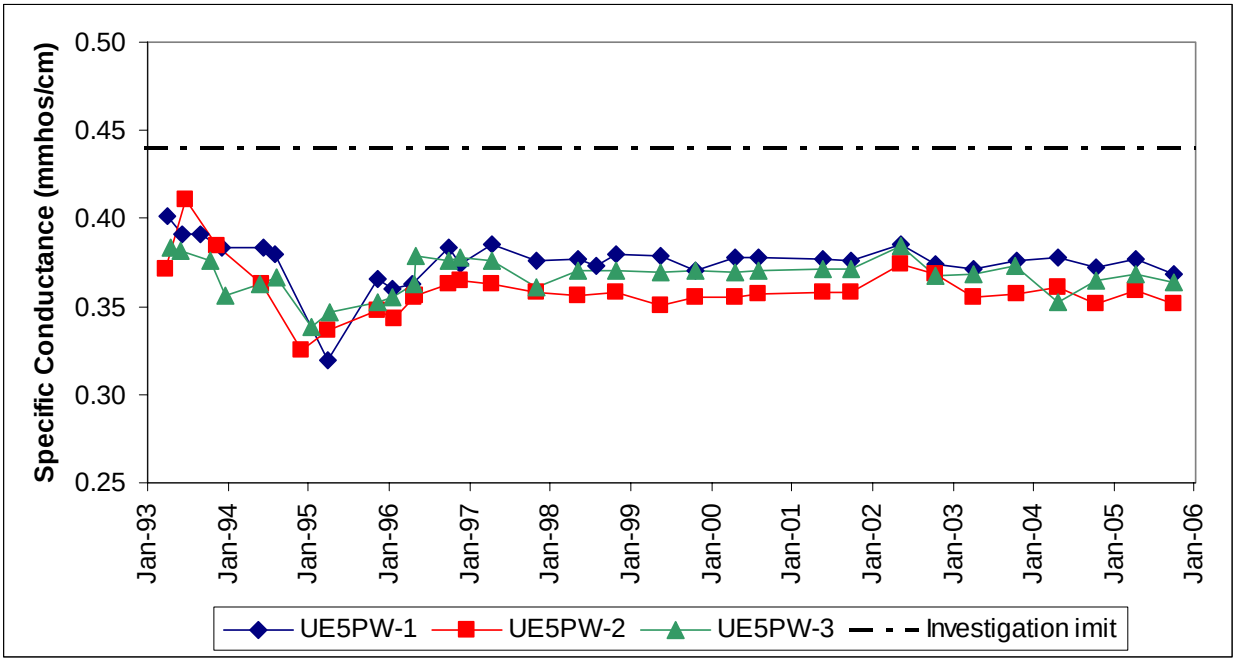


Figure 7 Area 5 RWMS Time Series Plot of Specific Conductance

C. Total Organic Carbon

All measured TOC values for the 2005 well samples were below the IL of 1 mg/L (Table 4). In 2005, three samples were collected from each well on each sample date and the averages of the three sample measures are reported. When sample TOC values fell below the sample's MDL of 0.5 mg/L, then 0.5 mg/L was the value used in calculating the reported average. Values shown as <0.5 mg/L indicate that all three sample results were less than the MDL.

TOC values have remained relatively stable and below the IL throughout the monitoring period (Figure 8). Most variation in TOC values is the result of variation in the MDL. No groundwater contamination is indicated by the TOC monitoring results.

Table 4 Area 5 RWMS Total Organic Carbon (TOC) Values in mg/L

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
March 1993	<1.0	<1.0	No sample
April 1993	No sample	No sample	<1.0
June 1993	No sample	<1.0	<1.0
July 1993	<1.0	No sample	No sample
September 1993	<1.0	No sample	No sample
October 1993	No sample	No sample	<1.0
November 1993	No sample	<1.0	No sample
December 1993	<1.0	No sample	<1.0
January 1994	No sample	<1.0	No sample
June 1994	No sample	<1.0	No sample
August 1994	1.7[a]	No sample	<1.0
November 1994	No sample	<1.0	No sample
January 1995	0.2	0.5	0.22
April 1995	<1.0	<1.0	<1.0
November 1995	<1.0	<1.0	<1.0
April 1996	<0.3	<0.3	<0.3
October 1996	<0.3	<0.3	<0.3
November 1996	<0.3	<0.3	<0.3
April 1997	<0.3	<0.3	<0.3
November 1997	<0.3	<0.3	<0.3
May 1998	<1.0	<1.0	<1.0
October 1998	<1.0	<1.0	<1.0
May 1999[b]	<1.0	<1.0	<1.0
October 1999[b]	<1.0	1.6[a]	<1.0
December 1999	No sample	<0.5	No sample
April 2000	0.98[a]	0.60[a]	1.31[a]
August 2000	<0.5[c]	<0.5[c]	<0.5[c]
May 2001	0.51[c]	<0.5[c]	0.53[c]
October 2001	<0.5	<0.5	<0.5
May 2002	<0.5	<0.5	<0.5
October 2002	<0.5	0.55	0.58
April 2003	0.51	0.58	0.52
October 2003	0.64	0.68	0.62
May 2004	0.55	<0.5	0.58
October 2004	0.58	0.90	0.83
April 2005	0.65	0.62	0.50
October 2005	0.60	0.53	<0.5

(a) Determined to be a false positive through resampling.
(b) Data from BN, 2001.
(c) Multiple laboratories used, this value represents the Lionville Laboratory Incorporated result only.

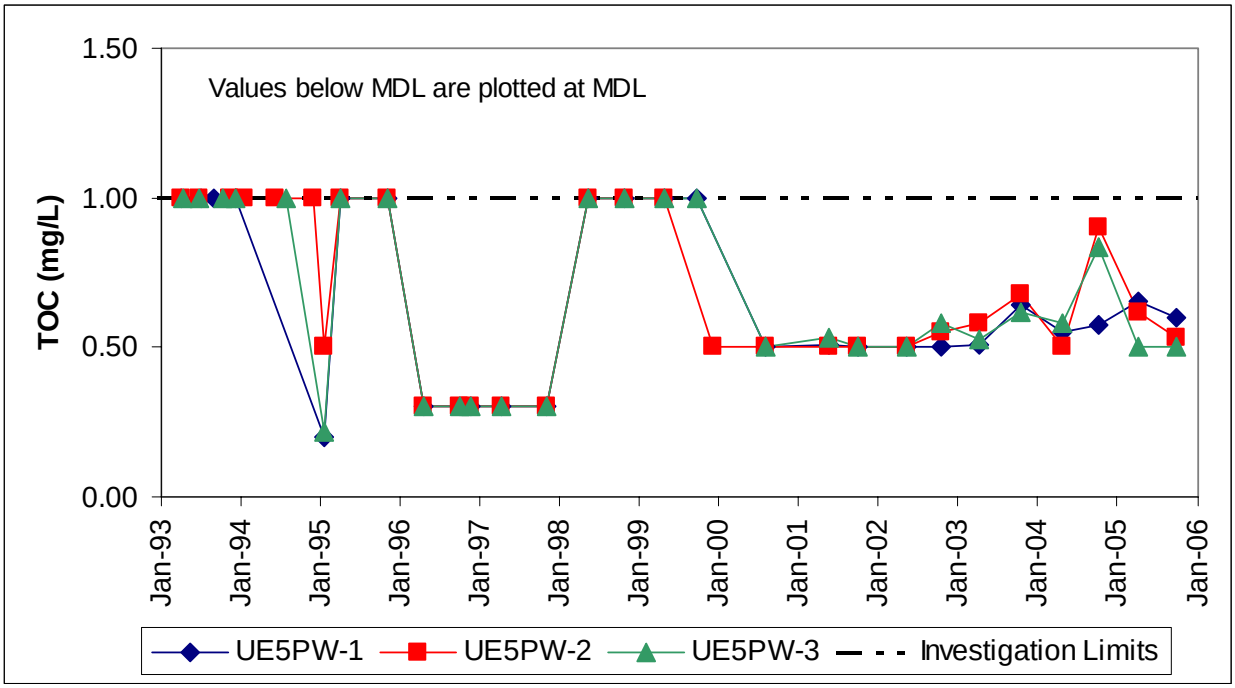


Figure 8 Area 5 RWMS Time Series Plot of Total Organic Carbon

D. Total Organic Halides

All 2005 TOX results are below the IL of 50 µg/L (Table 5). In 2005, three samples were collected from each well on each sample date and the averages of the three sample measures are reported. When sample TOC values fell below the sample's MDL of 5.0 µg/L, then 5.0 µg/L was the value used in calculating the reported average. Values shown as <5.0 µg/L indicate that all three samples were less than the MDL.

TOX values have remained relatively stable and below the IL throughout the monitoring period (Figure 9). No groundwater contamination is indicated by the TOX results.

Table 5 Area 5 RWMS Total Organic Halide (TOX) Values in µg/L

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
March 1993	20	23	No sample
April 1993	No sample	No sample	<10
June 1993	No sample	<10	20[a]
July 1993	<10	No sample	No sample
September 1993	20[a]	<10	No sample
October 1993	No sample	No sample	<10
November 1993	No sample	<10	No sample

Table 5 (continued)

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
December 1993	<10	No sample	<10
January 1994	No sample	<10	No sample
June 1994	<10	<10	No sample
August 1994	12[a]	No sample	<10
November 1994	No sample	14[a]	No sample
January 1995	<10	<10	<10
April 1995	<10	<10	<10
November 1995	<40	<40	<40
April 1996	<40	<40	<40
October 1996	<20	<20	<20
November 1996	<20	<20	<20
April 1997	<20	<20	<20
November 1997	<20	<20	<20
May 1998	391[c]	842[c]	1000[c]
July 1998	<5	No sample	No sample
October 1998	<5	<5	<5
May 1999[b]	<5	<5	<5
October 1999[b]	<5	<5	9[a]
April 2000	71.7[c]	59.3[c]	56.5[c]
August 2000	91.8[c,d]	73.0[c,d]	82.8[c,d]
May 2001	<12.6[d]	<12[d]	<12[d]
October 2001	<6.1	<5.8	<5.2
May 2002	<5.2	5.43	<5.2
October 2002	<5.2	<5.2	<5.2
April 2003	<5.2	<5.2	<5.2
October 2003	<5.2	5.5	<5.2
May 2004	<5.2	<5.2	<5.2
October 2004	<5.2	<5.2	<5.2
April 2005	<5.0	<5.0	<5.0
October 2005	5.2	6.5	<5.0

(a) Duplicate sample results were less than MDL.
(b) Data from BN, 2001.
(c) Determined to be false positive through resampling.
(d) Multiple laboratories used, this value represents the Lionville Laboratory Incorporated result only.

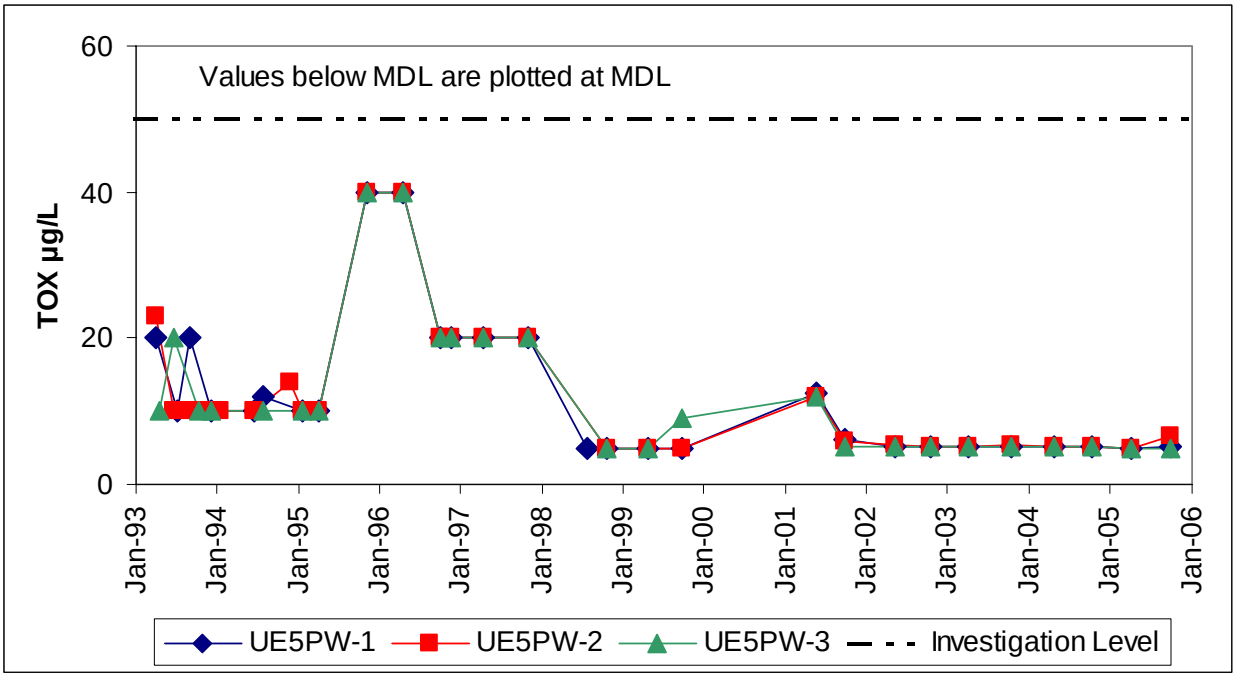


Figure 9 Area 5 RWMS Time Series Plot of Total Organic Halides

E. Tritium

All tritium results from 2005 water samples were below the IL of 2,000 pCi/L and below the laboratory MDC of approximately 20 pCi/L (Table 6). When duplicate samples were analyzed, Table 6 reports an average value. A reanalysis of the sample from UE5PW-1 in May 2004 initially reported as 33.96 pCi/L gave a new result of -8.14 pCi/L. The duplicate sample result is 2.75 pCi/L.

Tritium values have remained relatively stable and below the IL and MDC throughout the monitoring period (Figure 10). No groundwater contamination is indicated by the tritium results.

Table 6 Area 5 RWMS Tritium Values in pCi/L

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
April 1993	No sample collected	No sample collected	1.96
March 1993	0.442	-4.28	No sample collected
June 1993	No sample collected	No sample collected	-2.74
November 1993	No sample collected	32.2[a]	No sample collected
December 1993	-1.58	No sample collected	-0.459
January 1994	No sample collected	3.69	No sample collected
May 1994	No sample collected	No sample collected	1.13
June 1994	-2.04	1.29	No sample collected
August 1994	1.86	No sample collected	1.04

Table 6 (continued)

Date Sampled	UE5PW-1	UE5PW-2	UE5PW-3
November 1994	No sample collected	0.0148	No sample collected
April 1995	2.80	-0.920	1.50
April 1996	-1.72	-1.91	-2.29
April 1997	3.15	0.189	3.69
May 1998	-2.35	-1.95	-4.71
October 1998	-1.09	-1.85	-8.25
May 1999[b]	5.17	4.23	4.60
October 1999[b]	-1.36	-3.37	1.08
April 2000[b]	-2.55	1.67	-0.08
August 2000[b]	-2.52	6.97	4.34
May 2001	-1.91	-11.5	-12.4
October 2001	-2.93	-2.82	2.46
May 2002	-2.82	0.151	-3.26
October 2002	-4.17	0.113	-1.17
April 2003	-1.13	-5.22	1.62
October 2003	0.950	11.4	0.405
May 2004	-2.69	-6.17	-6.04
October 2004	-1.50	-10.0	-6.38
April 2005	3.67	3.76	3.56
October 2005	8.82	5.24	-4.76

(a) Standard analysis performed, not enriched.
(b) Data from BN, 2001.

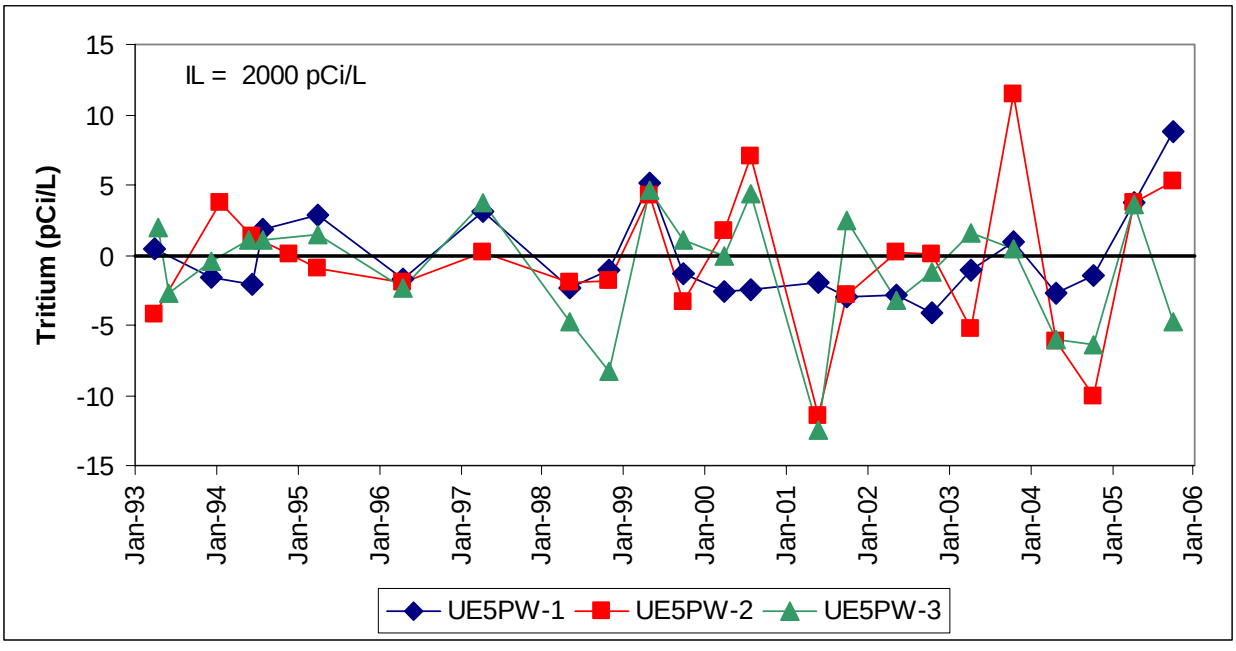


Figure 10 Area 5 RWMS Time Series Plot of Tritium

F. General Water Chemistry Parameters

General water chemistry analyses during 2005 for cations (Ca, Mg, Na, K, Fe), anions (Cl, F, SO_4, HCO_3) and silicate (SiO_2) indicate similar groundwater in all three wells and no changes in groundwater chemistry (Table 7, Table 8, Table 9).

Groundwater temperatures measured in May 2005 ranged from 17.7 to 19.7°C and in October 2005 ranged from 19.4 to 20.1°C. Temperature measurements are collected at the ground surface and are influenced by the ambient air temperature.

A piper diagram for 2004 and 2005 water chemistry data indicate that the groundwater is a sodium-bicarbonate type (Figure 11). Stiff plots for these years also indicate similar groundwater chemistry for all three wells and no changes in the groundwater chemistry (Figures 12 and 13).

G. Groundwater Elevation

Groundwater elevations in UE5PW-1, UE5PW-2, and UE5PW-3 are measured quarterly using an electronic water-level tape (Table 10; Figure 14). The 2005 average depths to water from top of casing are: 235.71 m (773.34 ft), 256.41 m (841.23 ft), and 271.49 m (890.70 ft) for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo, 1994).

The 2005 average groundwater elevations are: 733.66 m AMSL, 733.71 m AMSL, and 733.74 m AMSL for UE5PW-1, UE5PW-2, and UE5PW-3, respectively. These measurements are corrected for borehole deviation (REECo, 1994). Based on the similar groundwater elevations, the groundwater table is essentially flat with little or no flow. Groundwater gradient, velocity, and flow direction are calculated from the groundwater elevations, borehole locations, and aquifer hydraulic properties (Table 11, Appendix). The very low calculated flow velocities and the fluctuating flow directions indicate little or no groundwater flow.

III. SUMMARY

The hydrologic conditions in the uppermost aquifer beneath the Area 5 RWMS remain stable. Groundwater flow in this uppermost aquifer is negligible. No significant changes were detected in the water chemistry and all indicator parameters remain within the established ILs.

IV. CONCLUSION

There is no measurable impact to the uppermost aquifer from the Area 5 RWMS.

Table 7 UE5PW-1 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO_2	SO_4	HCO_3	Cl	Fl
3/31/1993	No analysis	No analysis	No analysis	48.0	<0.006	0.013	No analysis	32	167	9.2	1.2
6/6/1993	No analysis	No analysis	No analysis	58.0	<0.001	0.059	No analysis	37	161	9.7	1.4
9/1/1993	No analysis	No analysis	No analysis	56.0	0.0066	0.027	No analysis	No analysis	158	8.4	5.7
12/7/1993	No analysis	No analysis	No analysis	57.0	<0.0012	0.012	No analysis	36	150	9.9	1.5
6/15/1994	No analysis	No analysis	No analysis	61.0	<0.004	0.01	No analysis	No analysis	No analysis	10.0	No analysis
8/1/1994	No analysis	No analysis	No analysis	53.0	<0.0012	0.021	No analysis	36	No analysis	No analysis	No analysis
4/4/1995	No analysis	No analysis	No analysis	58.0	<0.01	<0.05	No analysis	34	No analysis	9.9	No analysis
4/16/1996	No analysis	No analysis	No analysis	61.0	<0.001	0.02	No analysis	34	No analysis	9.9	No analysis
4/16/1997	15.1	5.3	5.9	54.5	<0.001	0.012	No analysis	32.2	156	9.3	1.3
11/5/1997	15.5	5.6	6.4	57.8	No analysis	0.012	No analysis	35.2	151	10.2	1.2
5/13/1998	14.0	5.4	5.2	55.8	0.0015	0.034	54.2	34.6	151	9.6	1.1
10/28/1998	14.9	5.6	6.9	57.6	0.0015	0.024	60.5	34.0	160	No analysis	1.1
5/19/1999	12.5	5.3	6.9	61.0	<0.0025	<0.05	68.5	34.0	146	10.0	1.0
10/27/1999	14.5	6.0	6.6	63.5	<0.005	<0.1	62.0	35.0	159	8.7	1.1
4/26/2000	12.8	4.8	6.7	53.7	0.001	0.032	58.3	35.6	165	10.0	1.0
8/9/2000	15.0	4.9	6.6	52.0	0.00045	< 0.0164	59.9	37.1	146	10.3	1.1
5/29/2001	14.8	4.9	6.0	58.6	< 0.0018	0.0136	62.5	No analysis	144	13.2	<1.0
10/3/2001	13.8	4.9	6.7	51.0	0.00017	< 0.0156	58.6	35.8	145	10.1	<1.0
5/15/2002	14.0	4.9	6.9	53.8	0.00016	< 0.0145	59.9	36.1	156	10.8	1.0
10/22/2002	14.7	5.2	6.4	50.0	< 0.0002	< 0.0181	61.0	35.5	146	10.3	1.0
4/15/2003	13.7	5.0	6.2	58.0	< 0.0005	0.011	59.2	32.9	150	12.3	1.0
10/22/2003	14.0	5.0	6.0	58.0	< 0.0016	0.0152	61.0	36.5	No analysis	9.4	1.0
5/4/2004	12.8	4.6	6.5	55.3	0.0021	0.029	52.0	34.5	154	9.8	1.1
10/19/2004	13.1	5.2	6.0	56.2	< 0.0003	< 0.0279	59.9	37.3	168	10.1	1.0
4/19/2005	13.8	4.8	6.6	55.1	< 0.0006	0.007	58.6	39.6	149	10.5	1.0
10/11/2005	13.4	5.0	6.1	50.5	< 0.0002	< 0.0260	61.2	35.7	156	9.7	1.0

Data source: Data from 1993 through 2000 from BN, 2001.

Table 8 UE5PW-2 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO_2	SO_4	HCO_3	Cl	Fl
3/24/1993	No analysis	No analysis	No analysis	46	0.11	0.062	No analysis	28	159	8.4	1.0
6/22/1993	No analysis	No analysis	No analysis	54	0.032	0.25	No analysis	30	183	9.7	1.1
11/15/1993	No analysis	No analysis	No analysis	51	<0.004	0.180	No analysis	31	171	9.4	1.3
1/19/1994	No analysis	No analysis	No analysis	45	<0.0012	0.074	No analysis	29	159	No analysis	1.2
6/7/1994	No analysis	No analysis	No analysis	55	<0.004	0.14	No analysis	No analysis	No analysis	No analysis	No analysis
11/29/1994	No analysis	No analysis	No analysis	No analysis	No analysis	No analysis	No analysis	28	No analysis	8.0	No analysis
4/4/1995	No analysis	No analysis	No analysis	50	<0.01	<0.05	No analysis	28	No analysis	8.5	No analysis
4/30/1996	No analysis	No analysis	No analysis	51	<0.001	0.013	No analysis	29	No analysis	8.3	No analysis
4/16/1997	15.9	6.0	5.0	47.6	<0.001	0.012	No analysis	26.4	149	7.9	1.2
11/5/1997	17.4	6.8	4.9	50.6	No analysis	0.018	No analysis	28.9	140	8.6	0.9
5/13/1998	14.8	5.7	3.8	45.2	<0.0011	0.066	50.8	28.4	151	8.2	1.0
10/28/1998	15.8	6.2	5.6	47.4	0.0009	0.015	55.9	28.4	157	8.3	1.0
5/19/1999	15.0	6.3	6.2	52.0	<0.0025	<0.05	62.0	27.5	134	8.7	0.9
10/27/1999	16.0	6.7	5.7	52.0	<0.005	<0.1	55.6	28.0	159	7.4	1.0
4/26/2000	15.2	6.5	5.6	45.6	0.0007	0.029	55.8	29.1	180	8.6	0.8
8/9/2000	17.0	6.6	5.3	44.4	< 0.0002	< 0.0164	59.3	28.7	166	9.3	0.9
5/29/2001	16.7	6.6	4.8	48.2	< 0.0018	< 0.0107	60.3	No analysis	151	12.4	1.0
10/3/2001	16.0	6.7	5.5	44.5	0.0001	< 0.0156	59.0	28.4	151	8.6	1.0
5/15/2002	16.5	6.9	5.6	46.1	0.00053	0.0741	60.3	28.5	156	9.4	0.9
10/22/2002	17.7	7.1	5.3	44.4	< 0.0002	< 0.0181	63.1	29.0	149	8.6	0.9
4/15/2003	16.4	6.7	5.2	51.1	< 0.0005	< 0.0101	60.7	26.7	154	9.9	0.8
10/22/2003	16.1	6.6	5.2	49.6	< 0.0016	0.0618	60.5	29.5	141	8.8	0.9
5/4/2004	15.7	6.2	5.4	46.7	< 0.0007	0.0478	58.4	28.1	160	8.2	1.0
10/19/2004	15.7	6.7	5.1	48.6	< 0.0003	< 0.0279	59.7	29.6	169	8.9	0.9
4/19/2005	16.3	6.3	5.2	44.9	< 0.0006	0.0115	58.6	31.3	133	8.4	0.9
10/11/2005	16.0	6.8	5.0	44.0	< 0.0002	< 0.0270	62.2	29.0	167	8.1	0.9

Data source: Data from 1993 through 2000 from BN, 2001.

Table 9 UE5PW-3 General Water Chemistry Values in mg/L

Date	Ca	Mg	K	Na	Mn	Fe	SiO_2	SO_4	HCO_3	Cl	Fl
04/14/93	No analysis	No analysis	No analysis	46	0.042	0.024	No analysis	31	157	8.5	1.3
06/02/93	No analysis	No analysis	No analysis	53	0.009	0.014	No analysis	31	162	9.1	1.2
10/12/93	No analysis	No analysis	No analysis	57	<0.006	0.11	No analysis	30	156	7.9	1.2
12/20/93	No analysis	No analysis	No analysis	48	<0.0012	0.1	No analysis	33	156	8.7	1.3
05/24/94	No analysis	No analysis	No analysis	56	<0.0012	0.02	No analysis	No analysis	No analysis	No analysis	No analysis
08/08/94	No analysis	No analysis	No analysis	51	<0.0012	<0.009	No analysis	33	No analysis	8.9	No analysis
04/05/95	No analysis	No analysis	No analysis	55	<0.01	<0.05	No analysis	31	No analysis	8.8	No analysis
04/30/96	No analysis	No analysis	No analysis	57	<0.001	0.0088	No analysis	32	No analysis	8.7	No analysis
04/16/97	15.8	5.7	4.0	54.2	<0.001	<0.006	No analysis	29.0	155	8.4	1.3
11/05/97	16.8	6.1	4.3	55.5	No analysis	0.0133	No analysis	32.1	140	9.2	1.1
05/13/98	15.8	5.8	3.3	53.8	<0.0011	0.035	56.8	31.0	151	8.6	1.0
10/28/98	15.6	5.7	4.2	53.7	0.0009	0.009	57.1	31.4	156	8.7	1.0
05/19/99	15.0	5.8	4.8	56.0	<0.0025	<0.05	66.3	30.5	146	9.2	0.9
10/27/1999	16.0	6.4	3.8	58.5	<0.005	<0.1	59.9	31.0	159	7.6	0.9
4/26/2000	15.2	5.9	4.5	49.8	0.0003	0.014	58.5	32.0	169	9.1	0.9
8/9/2000	16.0	5.8	4.3	48.2	< 0.0002	< 0.016	57.8	32.6	162	9.9	1.0
5/29/2001	16.7	6.0	4.0	55.1	< 0.0018	< 0.0107	60.5	30.5	150	No analysis	No analysis
10/3/2001	15.6	6.0	4.5	48.5	< 0.0001	< 0.0156	58.0	31.5	151	8.9	<1.0
5/15/2002	15.9	6.1	4.5	49.8	0.00026	0.024	58.6	33.3	151	9.8	0.9
10/22/2002	17.1	6.1	4.2	47.5	< 0.0002	< 0.0181	60.3	32.1	150	9.2	0.8
4/15/2003	16.0	5.9	4.5	54.7	0.00083	0.0195	58.4	29.3	144	11.8	0.8
10/21/2003	16.3	5.8	4.1	54.4	< 0.0016	0.0212	59.5	32.5	160	9.2	1.0
5/4/2004	16.4	5.7	4.6	52.9	< 0.0007	0.0453	58.8	31.0	155	8.7	1.0
10/20/2004	15.6	5.9	4.0	52.3	< 0.0003	< 0.0279	58.4	32.0	166	9.4	0.8
4/19/2005	16.2	5.6	4.5	50.9	< 0.0006	0.0319	57.8	34.4	148	8.8	0.9
10/11/2005	16.1	6.1	4.3	48.5	< 0.0002	< 0.0260	61.4	32.5	156	8.5	0.9

Data source: Data from 1993 through 2000 from BN, 2001.

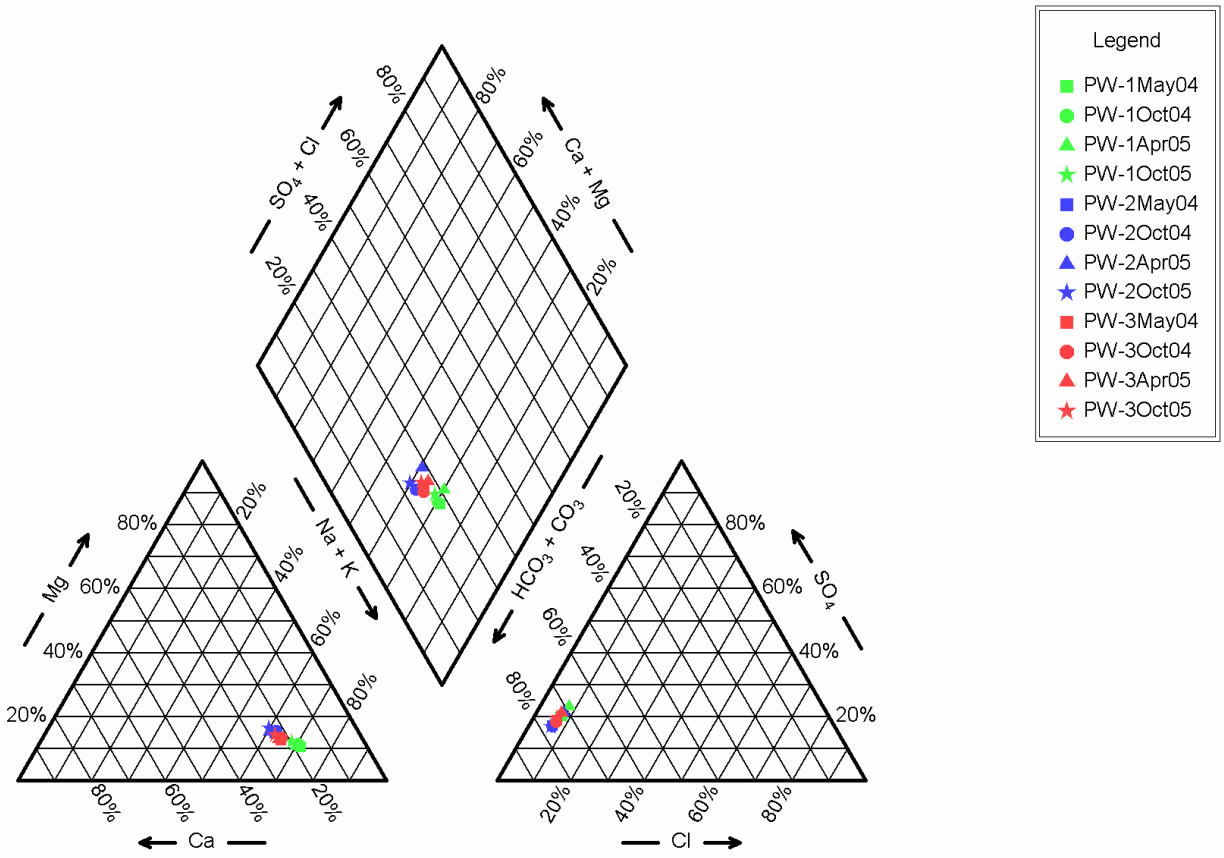


Figure 11 Area 5 RWMS Two-Year Piper Diagram

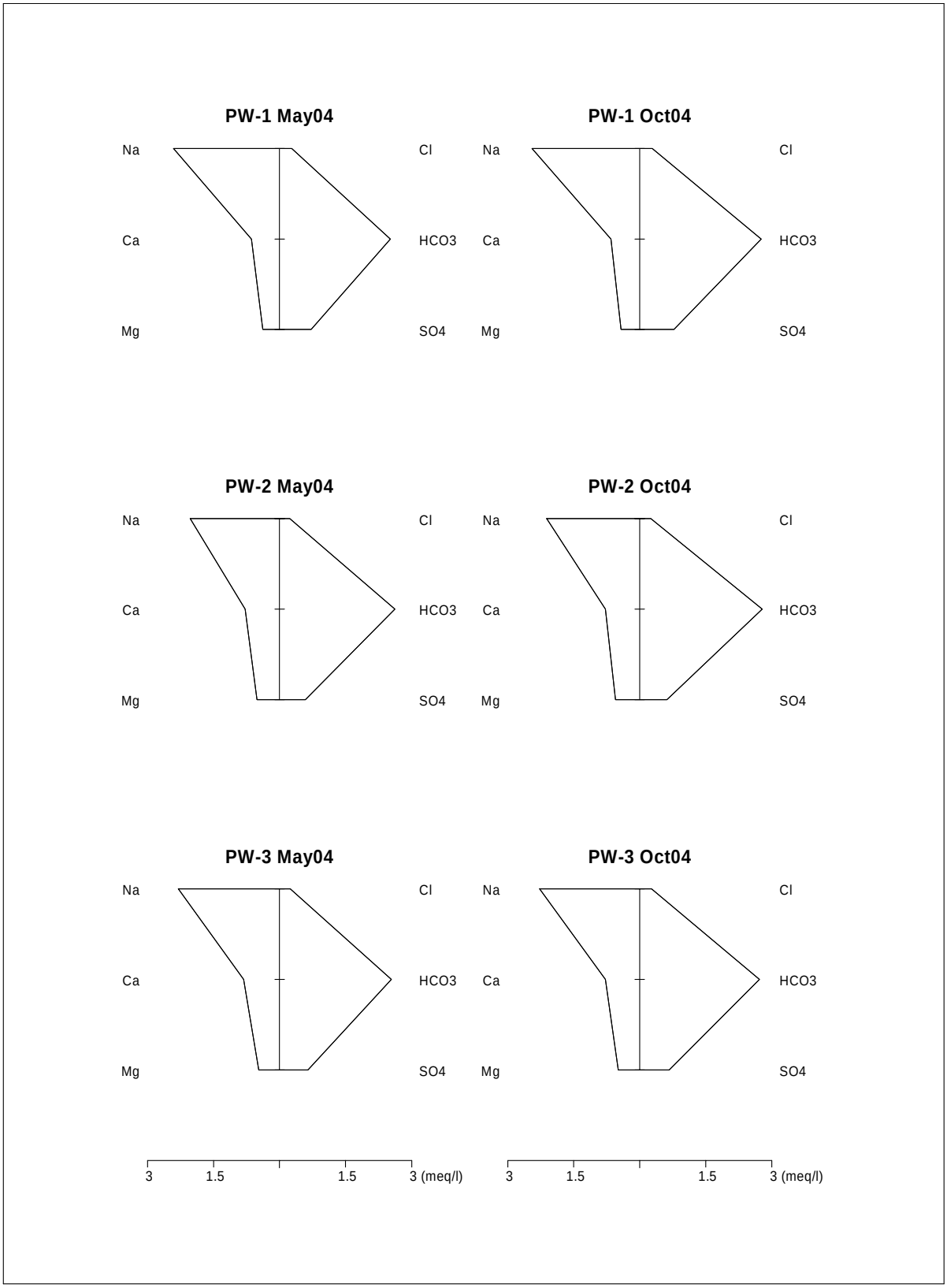


Figure 12 Area 5 RWMS Stiff Diagrams 2004

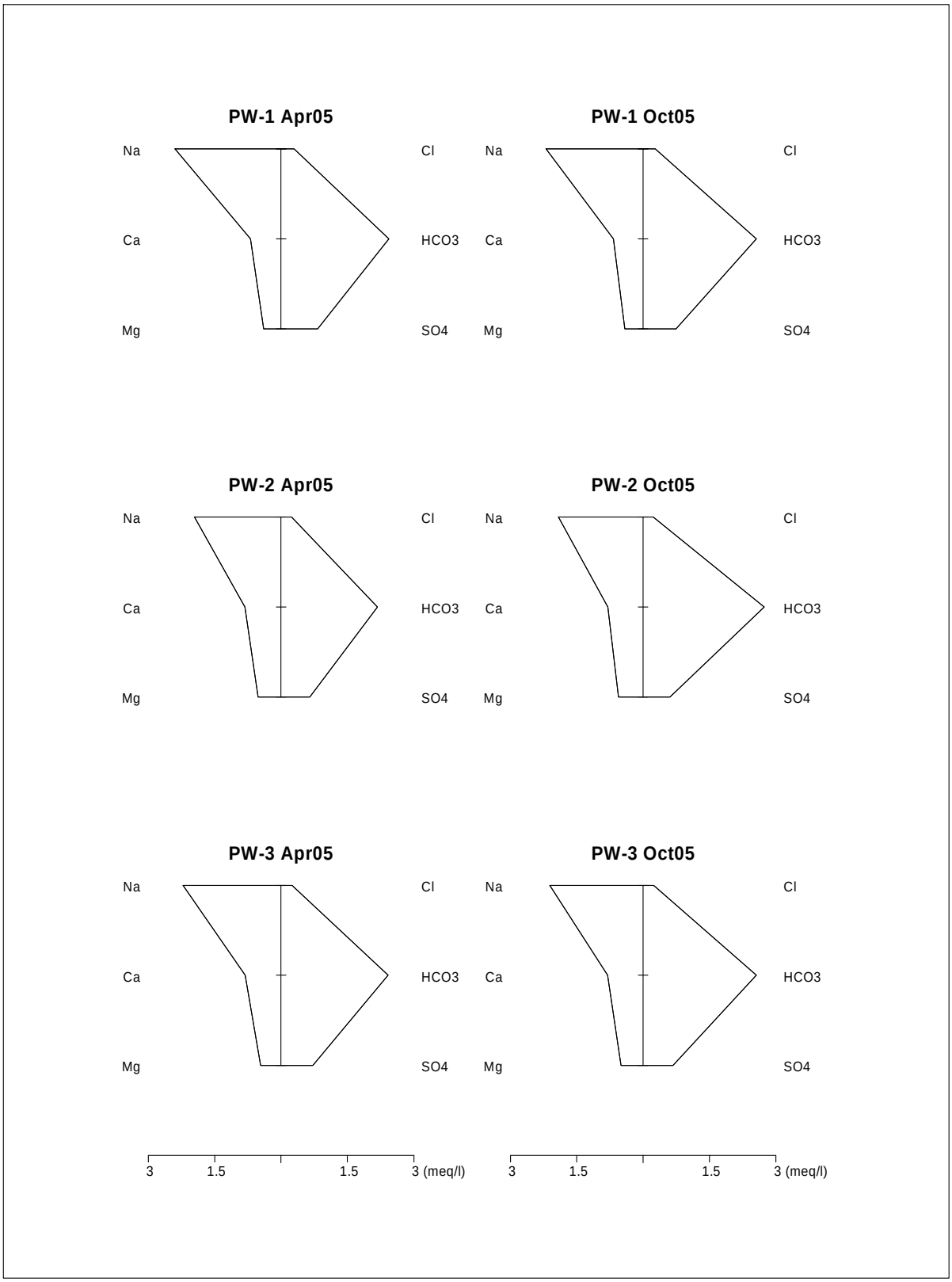


Figure 13 Area 5 RWMS Stiff Diagrams 2005

Table 10 Area 5 RWMS Groundwater Elevation Data

Well Characteristics[a]	UE5PW-1		UE5PW-2		UE5PW-3	
Northing[b] (m)	233,386.48		234,817.13		235,089.93	
Easting[b] (m)	216,357.08		216,376.00		214,415.04	
Well Casing Elevation[c] (m)	969.37		990.12		1,001.92	
Casing stickup height[d] (m)	0.72		0.68		0.76	
Land Surface Elevation (m)	968.65		989.44		1,001.16	
Borehole Deviation Correction (m)	0.08		0.21		0.02	
Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
03/22/1993	235.55	733.82	256.38	733.74	271.69	733.53
03/23/1993	235.53	733.85	256.48	733.64	271.68	733.54
03/24/1993	235.53	733.84	256.36	733.76	271.69	733.53
03/25/1993	235.53	733.85	256.35	733.77	271.69	733.53
03/29/1993	235.59	733.78	256.38	733.74	271.73	733.49
03/30/1993	235.62	733.75	256.43	733.69	271.75	733.47
03/31/1993	235.62	733.75	256.44	733.67	271.74	733.48
04/01/1993	235.54	733.83	256.37	733.75	271.69	733.53
04/05/1993	235.51	733.86	256.35	733.77	271.67	733.55
04/06/1993	235.59	733.78	256.40	733.71	271.75	733.47
05/10/1993	235.64	733.73	256.46	733.66	271.76	733.46
05/11/1993	235.56	733.81	256.42	733.70	271.70	733.52
05/12/1993	235.54	733.83	256.40	733.72	271.72	733.50
05/13/1993	235.61	733.76	256.45	733.67	271.75	733.47
05/17/1993	235.61	733.76	256.45	733.67	271.74	733.49
05/18/1993	235.59	733.78	256.45	733.67	271.74	733.48
05/19/1993	235.59	733.78	256.44	733.67	271.73	733.49
05/20/1993	235.54	733.83	256.39	733.72	271.70	733.52
05/24/1993	235.60	733.77	256.43	733.69	271.74	733.48
05/25/1993	235.61	733.76	256.45	733.67	271.74	733.48
06/01/1993	235.58	733.79	256.43	733.68	271.73	733.49
06/07/1993	235.64	733.73	256.46	733.66	271.76	733.46
06/14/1993	235.61	733.76	256.46	733.66	271.74	733.49
06/21/1993	235.58	733.79	256.43	733.68	271.73	733.50
07/26/1993	235.59	733.78	256.45	733.67	271.74	733.49
08/03/1993	235.54	733.83	256.42	733.70	271.70	733.52
08/09/1993	235.62	733.75	256.46	733.66	271.75	733.47
08/16/1993	235.59	733.78	256.42	733.70	271.73	733.50
08/30/1993	235.58	733.79	256.43	733.69	271.72	733.50
12/28/1993	235.59	733.78	256.47	733.65	271.74	733.48

Table 10 (continued)

Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
01/03/1994	235.57	733.80	256.44	733.68	271.70	733.53
02/02/1994	235.53	733.84	256.44	733.68	271.66	733.57
02/22/1994	235.60	733.77	256.43	733.69	271.71	733.51
02/28/1994	235.60	733.78	256.45	733.67	271.70	733.53
03/07/1994	235.54	733.83	256.38	733.74	271.66	733.56
03/14/1994	235.55	733.82	256.45	733.67	271.67	733.55
03/21/1994	235.56	733.81	256.38	733.74	271.68	733.54
03/28/1994	235.63	733.74	256.47	733.64	271.70	733.53
04/04/1994	235.53	733.85	256.40	733.72	271.66	733.56
04/13/1994	235.55	733.82	256.43	733.69	271.65	733.57
04/20/1994	235.51	733.86	256.38	733.74	271.64	733.58
04/26/1994	235.55	733.82	256.35	733.77	271.65	733.57
01/18/1995	235.63	733.75	256.45	733.67	271.62	733.60
04/03/1995	235.57	733.80	256.39	733.73	271.61	733.61
01/16/1996	235.36	734.01	256.13	733.99	271.35	733.87
04/15/1996	235.56	733.81	256.30	733.82	271.43	733.79
10/01/1996	235.54	733.83	256.32	733.80	271.51	733.71
11/19/1996	235.59	733.78	256.33	733.79	271.52	733.70
03/03/1997	235.54	733.83	256.30	733.82	271.41	733.81
04/15/1997	235.63	733.74	256.40	733.72	271.54	733.68
06/18/1997	235.61	733.76	256.40	733.72	271.52	733.71
07/28/1997	235.60	733.77	256.37	733.75	271.51	733.71
08/20/1997	235.52	733.85	256.29	733.83	271.44	733.78
09/25/1997	235.59	733.78	256.35	733.77	271.49	733.73
10/27/1997	235.57	733.80	256.34	733.78	271.48	733.74
11/03/1997	235.65	733.72	256.40	733.72	271.55	733.67
11/06/1997	235.57	733.80	256.36	733.75	271.48	733.74
11/12/1997	235.66	733.71	256.45	733.67	271.54	733.68
11/13/1997	235.60	733.77	256.29	733.83	271.49	733.73
11/19/1997	235.63	733.74	256.42	733.70	271.55	733.67
11/20/1997	235.65	733.72	256.43	733.69	271.57	733.65
11/25/1997	235.64	733.73	256.39	733.73	271.54	733.68
11/26/1997	235.50	733.87	256.27	733.85	271.45	733.77
12/03/1997	235.71	733.66	256.43	733.68	271.60	733.62
01/26/1998	235.72	733.65	256.47	733.65	271.60	733.62
05/12/1998	235.60	733.77	256.32	733.80	271.52	733.70
10/27/1998	235.52	733.85	256.21	733.91	271.36	733.86
12/22/1998	235.54	733.83	256.20	733.92	271.35	733.87
02/02/1999	235.61	733.76	256.34	733.78	271.42	733.80
05/18/1999	235.56	733.81	256.26	733.85	271.35	733.87
08/25/1999	235.56	733.81	256.26	733.85	271.38	733.84
10/26/1999	235.57	733.80	256.26	733.86	271.34	733.88
04/24/2000	235.64	733.73	256.34	733.78	271.52	733.71
08/07/2000	235.59	733.78	256.30	733.82	271.47	733.75
11/13/2000	235.66	733.71	256.34	733.78	271.45	733.77
02/22/2001	235.57	733.80	256.26	733.86	271.38	733.85
05/21/2001	235.67	733.70	256.35	733.77	271.49	733.73
08/01/2001	235.66	733.71	256.36	733.76	271.48	733.74
10/01/2001	235.66	733.71	256.35	733.77	271.45	733.77
02/26/2002	235.76	733.61	256.43	733.69	271.52	733.70

Table 10 (continued)

Date	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)	Depth to Water (m below Top of Casing)	Water Table Elevation (m)
05/13/2002	235.65	733.72	256.39	733.73	271.44	733.78
08/19/2002	235.61	733.76	256.28	733.84	271.42	733.81
10/21/2002	235.61	733.76	256.31	733.81	271.44	733.78
02/26/2003	235.65	733.72	256.28	733.84	271.43	733.79
04/10/2003	235.61	733.76	256.30	733.82	271.41	733.82
09/10/2003	235.74	733.63	256.35	733.77	271.50	733.72
10/20/2003	235.73	733.64	256.42	733.70	271.53	733.69
02/25/2004	235.78	733.59	256.36	733.76	271.52	733.70
04/27/2004	235.72	733.65	256.43	733.68	271.52	733.70
08/18/2004	235.72	733.65	256.38	733.74	271.48	733.74
10/18/2004	235.71	733.66	256.29	733.82	271.47	733.75
01/26/2005	235.67	733.70	256.45	733.67	271.46	733.76
04/18/2005	235.66	733.71	256.33	733.79	271.44	733.78
07/27/2005	235.75	733.62	256.42	733.70	271.51	733.71
10/10/2005	235.77	733.60	256.44	733.67	271.54	733.68

[a] Source for northings, eastings, well casing elevations, and borehole deviation corrections: REECO, 1994
[b] Coordinate System: Nevada (Central) State Plane NAD27
[c] Measured from top of well casing
[d] Measured from top of well casing to land surface
Note: All elevations are m above mean sea level

Table 11 2005 Area 5 RWMS Groundwater Flow Calculations

Hydraulic Conductivity = 1.12E-03 cm/s (3.67E-05 ft/s)[a] **Effective Porosity = 0.38[a]**			
Date	**Hydraulic Gradient (m/m)**	**Velocity (m/yr)**	**Flow direction (degrees East of North)**
01/26/2005	5.40E-05	0.05	70.0
04/18/2005	5.63E-05	0.05	11.1
07/27/2005	5.76E-05	0.05	3.3
10/10/2005	5.54E-05	0.05	3.1

[a] Source: REECO, 1994

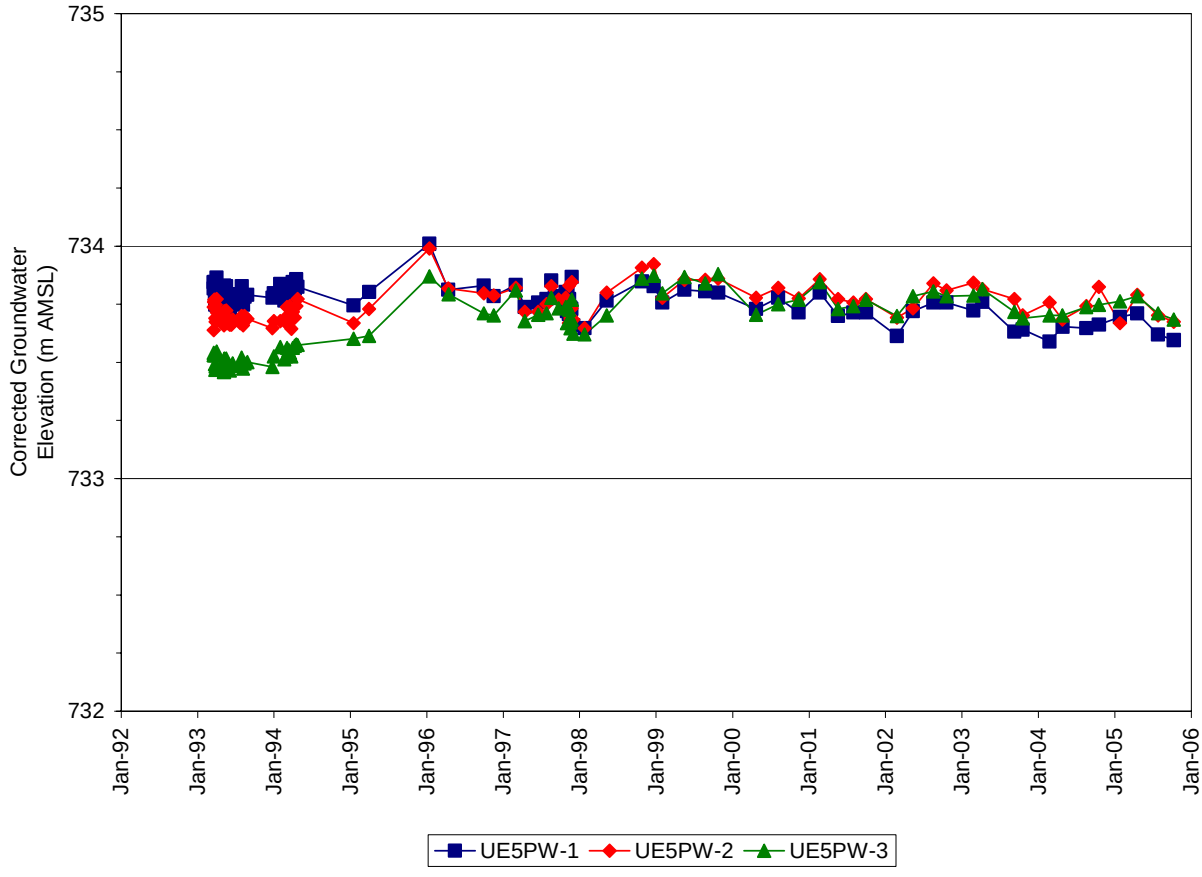


Figure 14 Area 5 RWMS Time Series Plot of Groundwater Elevation

References

Bright, D.J., Watkins, S.A., and Lisle, B.A., 2001. *Analysis of Water Levels in the Frenchman Flat Area, Nevada Test Site*. U.S Geological Survey Water-Resources Investigations Report 00-4272.

Bechtel Nevada, 1998. *Revised Area 5 Radioactive Waste Management Site, Outline of a Comprehensive Groundwater Monitoring Program*. Report to U.S. Department of Energy, Nevada Operations Office. February 1998.

Bechtel Nevada, 2001. *Nevada Test Site 2000 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Site*. Report to U. S. Department of Energy, National Nuclear Security Administration, Nevada Site Office, February 2001. DOE/NV/11718--511.

Bechtel Nevada, 2005. *Nevada Test Site 2004 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Site*. Report to U. S. Department of Energy, National Nuclear Security Administration, Nevada Site Office, February 2004. DOE/NV/11718--1015.

Code of Federal Regulations, 1999. *Ground-Water Monitoring*. Title 40, Part 265, Subpart F.

International Technology, Corporation, 1998. *Underground Test Area Subproject Corrective Action Unit 98: Frenchman Flat Data Analysis Task, Vol. 1 - Hydrostratigraphic Model Documentation Package*. Revision 0. Las Vegas, Nevada.

Laczniak, R.J., Cole, J.C., Sawyer, D.A., and Trudeau, D.A., 1996. *Summary of the Hydrogeologic Control at the Nevada Test Site, Nye County, Nevada.* U.S. Geological Survey Water-Resources Investigations Report 96-4109.

Liebendorfer, P.J., 2000. Nevada Division of Environmental Protection, Carson City, Nevada, Letter to R.C. Wycoff, U.S. Department of Energy Nevada, Operations Office, Las Vegas, NV. *1999 Annual Groundwater Monitoring Report, Area 5 Radioactive Waste Management Site (RWMS).* April 17, 2000.

Rehfelt, K., 2001. Nevada Test Site regional Groundwater Flow Lines. Written communication. Geotrans. Las Vegas, Nevada.

Reynolds Electrical & Engineering Co., Inc., 1994. *Site Characterization and Monitoring Data from Area 5 Pilot Wells, Nevada Test Site, Nye County, Nevada*. U.S. Department of Energy Report DOE/NV/11432--74.

U.S. Geological Survey, 2005. *USGS/USDOE Cooperative Studies in Nevada, Water-Levels Wells Site Map, Nevada Test Site*. December 5, 2005. http://nevada.usgs.gov/doe_nv/ntsmap.htm

This Page Intentionally Left Blank

Distribution

NNSA/NSO

J. T. Carilli, Project Manager, Waste Management Division, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration, P.O. Box 98518, Las Vegas, NV 89193-8518, M/S 505

E. F. Di Sanza, Director, Waste Management Division, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration, P.O. Box 98518, Las Vegas, NV 89193-8518, M/S 505

K. M. Small, Project Manager, Waste Management Division, Nevada Site Office, U.S. Department of Energy, National Nuclear Security Administration, P.O. Box 98518, Las Vegas, NV 89193-8518, M/S 505

BN

M. R. Dolenc, Environmental Management, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NSF083

D. B. Hudson, Environmental Technical Services, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NTS273

G. C. Henckel III, Environmental Management, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NSF081

C. F. Lohrstorfer, Environmental Technical Services, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NTS273

S. J. Nacht, Environmental Management, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NSF083

C. Ramirez, Environmental Management, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NLV083

T. J. Redding, Environmental Technical Services, Bechtel Nevada, P.O. Box 98521, Las Vegas, NV 89193-8521, M/S NTS273

Libraries

U.S. Department of Energy, Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831-0062 (electronic copy)

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, Public Reading Facility, c/o Nuclear Testing Archive, P.O. Box 98521 M/S 400, Las Vegas, NV 89193-8521

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office, Technical Library, P.O. Box 98518, M/S 505, Las Vegas, NV 89193-8518

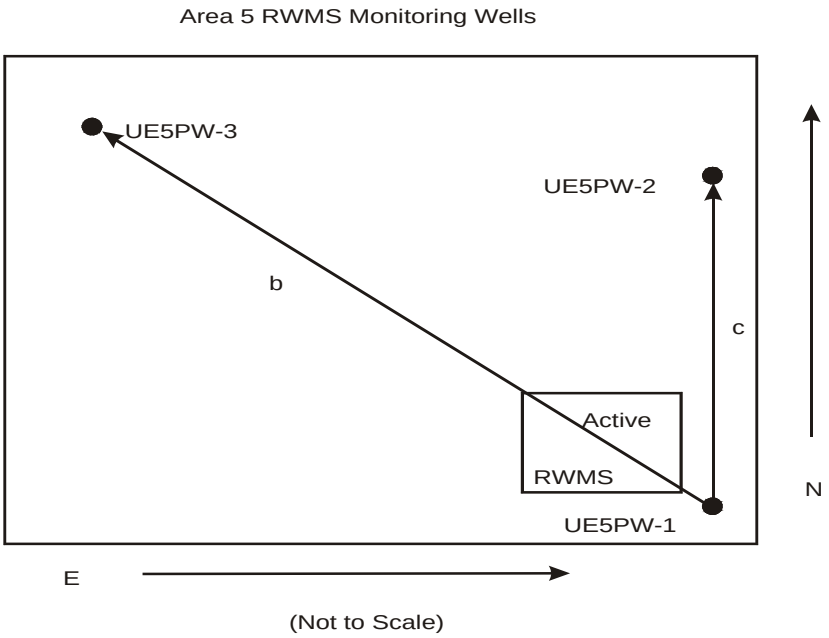
Appendix

Gradient/Velocity Calculations

This Page Intentionally Left Blank

CALCULATION OF MAGNITUDE AND DIRECTION OF AREA 5 ALLUVIAL AQUIFER GRADIENT

Water level elevations measured at three wells in the alluvial aquifer near the Area 5 RWMS are used to calculate the magnitude and direction of the hydraulic gradient. The wells sampled are UE5PW-1, UE5PW-2, and UE5PW-3. The locations of the three wells are given in Nevada State Central Zone coordinates in meters as Northing (N) and Easting (E) values (see figure below).



The coordinates of each of the three points on the plane are given by (E, N, e)
Where:
E is the East coordinate,
N is the North coordinate,
and e is the water table elevation.

The vector **b** representing the line segment 13 is given by $(E_3-E_1)\mathbf{l} + (N_3-N_1)\mathbf{j} + (e_3-e_1)\mathbf{k}$. Similarly the vector **c** representing the line segment 12 is given by $(E_2-E_1)\mathbf{l} + (N_2-N_1)\mathbf{j} + (e_2-e_1)\mathbf{k}$. A normal vector to the plane is given by the vector product of **b** and **c**.

$$\mathbf{b} \times \mathbf{c} = \begin{matrix} \mathbf{I} & \mathbf{j} & \mathbf{k} \\ [E_2-E_1] & [N_2-N_1] & [e_2-e_1] \\ [E_3-E_1] & [N_3-N_1] & [e_3-e_1] \end{matrix}$$

Expanding the determinant gives,

$$\mathbf{[}\,[N_2-N_1]\;[e_3-e_1] \;-\; [N_3-N_1]\;[e_2-e_1]\,\mathbf{]}\;\mathbf{I} -$$
$$\mathbf{[}\,[E_2-E_1]\;[e_3-e_1] \;-\; [E_3-E_1]\;[e_2-e_1]\,]\;\mathbf{j} +$$
$$\mathbf{[}\,[E_2-E_1]\;[N_3-N_1] \;-\; [E_3-E_1]\;[N_2-N_1\,]\mathbf{]}\;\mathbf{k}.$$

This gives the representation for the plane as,

$$A\,(E) + B\,(N) + C\,(e) = D$$

Where:

$$A = [N_2-N_1]\,[e_3-e_1] \;-\; [N_3-N_1]\,[e_2-e_1]$$

$$B = -\mathbf{[}[E_2-E_1]\,[e_3-e_1] \;-\; [E_3-E_1]\,[e_2-e_1]\mathbf{]}$$

$$C = [E_2-E_1]\,[N_3-N_1] \;-\; [E_3-E_1]\,[N_2-N_1].$$

The constant D can be determined by substituting the N, E, and e values for PW-1 into the equation for the plane.

The equation is then written in terms of the elevation:

$$e = -A/C\,(E) - B/C\,(N) + D/C.$$

The gradient is given by the derivative of the function e in the direction of the unit vector **u**.

$$D_u e = \nabla e \bullet \mathbf{u}$$

∇e points in the direction **u** that produces the largest directional derivative. $|\nabla e|$ is that largest directional derivative. For the water table elevations,

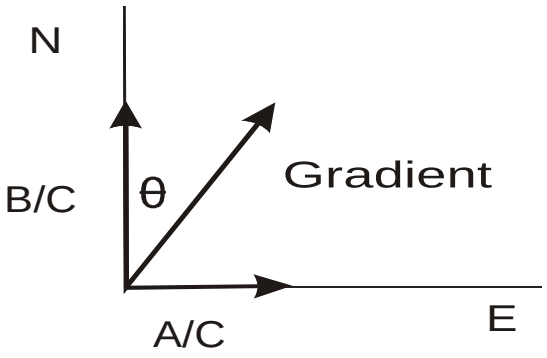
$$\nabla e = -A/C\,\mathbf{I} + B/C\,\mathbf{j}.$$

The gradient is calculated from the E and N components,

$$\text{Gradient} = \sqrt{(A/C)^2 + (B/C)^2}$$

The direction of the gradient with respect to North is calculated from the component vectors.

The direction of the gradient is given by:



$\theta = 90 - \text{Arctan}(B/A)$.

Calculation of Mean Groundwater Velocity

Once the gradient has been calculated, the mean groundwater velocity may be calculated using Darcy's Law:

$$q = Ki$$

where

$$V = q/\Phi$$

Where:

q equals the specific discharge or Darcian flux

K is the saturated hydraulic conductivity (length/time)

i is the hydraulic gradient (dimensionless)

Φ is the effective porosity (dimensionless)

V is the mean groundwater velocity (length/time)

This Page Intentionally Left Blank